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A NEW GENUS AND TWO NEW SPECIES OF SCUTACARID MITES (ACARINA) PHORETIC UPON BEES[1]

Robert E. Beer[2] and Earle A. Cross[2]

In the course of preliminary investigations of their acarine associates, large numbers of pinned bees in the Snow Entomological Museum at The University of Kansas were examined for mites. Information concerning the numbers, locations, and, insofar as possible, habits (e.g., parasitic or merely phoretic) of the latter were noted. Groups most frequently encountered were Uropodina, Acaridae, Anoetidae, Glyciphagidae, Pyemotidae and Scutacaridae. Among the several unusual forms found were the two new species of scutacarids described below.

The association of scutacarids with bees has been noted by many authors (cf., Gros, 1845, Michael, 1884 and 1885, Banks, 1905, Cockerell, 1905, and others), but studies of relationships between the two have been neglected except for *a priori* claims of parasitism deduced from cheliceral form. It seems apparent from information obtained in the present as well as other studies, that scutacarids are quite variable in host specificity. Some species are seemingly restricted to closely related host species within a single genus, while others are found associated with several host genera. The new genus is known only from species of Australasian and Philippine *Nomia* (Halictidae). These species belong to different subgenera, one, *N. strigata*, to *Nomia sensu stricto*, another, *N. philippinensis*, to an unnamed group closely allied to the Nearctic subgenus *Epinomia*. Both groups are seemingly restricted to the Asia-Australian region.

Although the new genus has many specialized characters, it may be considered primitive in the shape and (in one species) the position of the peritremes, in the length of the middle segments of the legs, in the absence of a secondary invagination of the anterior ventral plate, in that it lacks specialized setae on sternum II, in the elongate form of the posterior vaginal sclerotization, and in that it lacks pinnacula on tibiotarsus I. It is most closely related to an undescribed *Scutacarus*-like form from New South Wales which, however, lacks the elongate gnathosoma.

Methods

Descriptions of the new species reported in this paper were based upon the holotype specimens in each case. In the descriptions, items in paren-

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[2] Department of Entomology, The University of Kansas, Lawrence, Kansas.

theses, except where obviously otherwise, refer to variation found within the type series. First figures denote range, X denotes mean. Because of the small number of specimens in the type series (9 and 4), and because it is very likely that these involve siblings, it was not considered proper to include the standard error of the mean.

Measurements of body length were delimited by the anteriormost margin of the propodosoma and the posteriormost margin of the opisthosoma, along the longitudinal axis of the body. Body widths were measured at the widest point of the body and at right angles to the longitudinal axis. Symbols used in species descriptions denote the following: cx=coxa, trfe=trochantofemur, ge=genu, ti=tibia, tita=tibiotarsus, ta=tarsus; T=tactile seta, S=sensory seta.

Nasutiscutacarus, new genus

DIAGNOSIS. Immediately separable from all other genera in the group by the elongate gnathosoma, the planate character of the first hysterosomal tergum, and the lack of pretarsus, claws, and pulvillus on leg IV. *Type: Nasutiscutacarus anthrenae*, new species.

FEMALE:

GNATHOSOMA. Greatly elongate, obcapitate, length more than twice width at widest point; palpi short, arising at approximately apical one-eighth of gnathosoma.

PROPODOSOMA. *Dorsum:* Completely covered by first hysterosomal tergum ("clypeus" of authors), inversely T-shaped, lateral arms bearing pseudostigmata and propodosomal setae, median arm dilated and heavily sclerotized anteriorly, about one and one-quarter times as long as one of lateral arms; two pairs propodosomal setae, medials distinctly longer than laterals; peritremes large, ovoid, diverging anteriorly and opening dorsally in anterior one-third of middle arm or opening anteriorly in propodosomal "shoulders." *Venter:* Vestlike, with deep median concavity providing for reception of gnathosoma, this concavity extending about four-fifths of distance to posterior margin of anterior ventral plate; apodemes II straight or slightly sinuate, complete or incomplete medially, making angle of approximately forty-five degrees with anterior median suture.

HYSTEROSOMA. *Dorsum:* Five distinct terga, first rather weakly sclerotized, hemielliptical or spade-shaped, about as long as remaining terga combined, flat or nearly so. *Venter:* Legs III and IV well separated; apodemes III distinct, complete or incomplete medially, bearing one or both pairs of presternal setae; apodemes IV short, incomplete laterally, directed toward or in front of anterior sternocoxal condyles of legs III; posterior median apodeme not meeting apodemes III, extending posteriorly approximately to line drawn between median sternocoxal condyles of legs IV.

LEGS. Segments well developed, not excessively short and bandlike, at least tibia III as long or longer than wide; tibiotarsus I lacking pinnacula, with circular, sclerotized, "specialized plate" along lateral margin midway between base and apex; claw I well developed, furnished with stout, opposable "thumb"; laterodorsal setae of trochantofemur I distinctly pinnate,

a flexible sensory seta with lanceolate apex arising from inner margin of same segment; sensory pegs of tibiae II and III present; coxae IV subrectangulate, not constricted basally, coxal seta well ventral; tibia and tarsus IV fused, line of fusion distinct or absent, pretarsus, claws, and pulvillus lacking; fused tibiotarsus as long as or longer than coxa IV, bearing six setae.

REMARKS. Only the non-gravid females are known. These have been found in the pleural or ventral mesosomal pubescence of certain Australasian and Philippine *Nomia* and are presumably inquiline associates of these bees.

Nasutiscutacarus anthrenae, new species
(Figs. 1-2)

FEMALE: Length, 273 μ (257-284, X=270); width, 186 μ (164-186, X=179); distance between anterior sternocoxal condyles of legs III, 106 μ (98-119, X=106); body elliptical in dorsal aspect.

GNATHOSOMA. Length, 88 μ (85-92, X=89); width at widest point, 35 μ (31-35, X=32).

PROPODOSOMA. *Dorsum:* Width between centers of internal pseudostigmatal sockets, 91 μ (85-96, X=89); peritremes ovoid, dorsal, diverging anteriorly, located in anterior third of mesal propodosomal arm. *Venter:* All ventral propodosomal setae sparsely plumose; sternal internals I[3] (41-51 μ long, X=46), slightly longer (to barely shorter) than sternal externals I; sternals II much shorter than other propodosomal setae, 15 μ long (13-17, X=15).

HYSTEROSOMA. *Dorsum:* First dorsal segment hemielliptical; all enlarged setae (includes dorsals I, II, III, and IV and laterals I) nude basally, spinulate apically, blunt or jagged at the tips; setae of first segment spaced subequally across dorsum, dorsals I 52 μ long (47-52, X=50), distance between them 50 μ (50-53, X=52), slightly closer to respective laterals than to each other and shorter than laterals, arising about one third their length anterior to laterals I; dorsals II subequal in length to laterals I, widely spaced, 109 μ apart (97-111, X=108), laterad to (or appearing directly beneath) dorsals III; dorsals III slightly longer than dorsals II, 72 μ (67-74, X=71) apart, laterals III nearly nude, 37 μ long (23-46, X=38), less than half width of dorsals III at base and arising distinctly anterolateral to them by much more than the diameter of the dorsal areolus; setae of the fourth segment spaced as setae of first, dorsals 39 μ apart, (39-43, X=41), equal to dorsals III in size, laterals slightly larger and more plumose than laterals III, 41 μ long (41-59, X=48); all three pairs setae of segment V equidistant, internal caudals longest, 48 μ (42-50, X=47), sparsely plumose, external caudals half as wide at base (or less), 41 μ[4] (13-41, X=29), nude; laterals V 15 μ (14-19, X=16) long, nude.

[3] This measurement of the holotype was not possible.

[4] These setae were abnormally large for the species (note mean) and in addition, the two members of the pair differed greatly in size. Discarding the measurements of the holotype, measurements of external caudals are (13-22, X = 17).

Venter: All setae of posterior ventral plate sparsely plumose; distance between anterior sternocoxal condyle of leg III and posterior margin of coxal foramen IV, 80 μ (74-86, X=80); apodemes III incomplete medially, bearing both pairs of presternals, these subequal in size; apodemes IV distinct only medially and laterally (or distinct only medially), mesal portion directed toward anterior sternocoxal condyles of legs III, lateral portion recurved and bearing second axillaries (Fig. 2), the latter subequal to presternals in size; external poststernals projecting beyond posterior margin of body, distinctly longer than all other setae of posterior ventral plate, internal poststernals approaching posterior body margin; posterior margin of opisthosomal sternum entire.

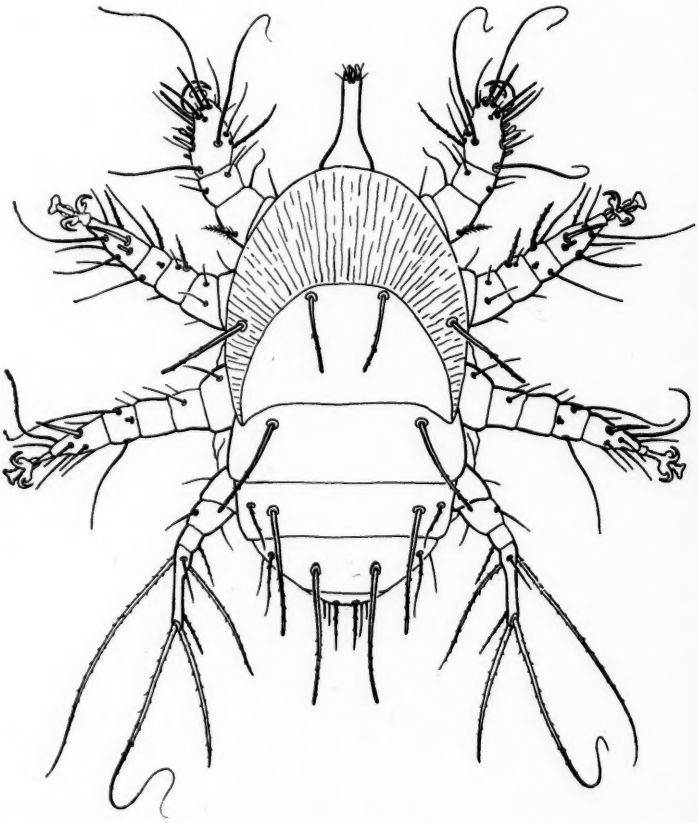

Fig. 1. *Nasutiscutacarus anthrenae*, new species. Dorsal aspect of holotype female.

LEGS. *Length:* Legs I, 96 μ long (83-97, X=92); legs II, 118 μ (107-121, X=116); legs III, 132 μ (119-141, X=133); legs IV, 124 μ (120-132, X=127). *Width:* Legs I, 30 μ (26-31, X=30); legs II, 26 μ (25-30, X=29); legs III, 25 μ (24-28, X=26); legs IV, 18 μ (15-19, X=17). *Segment lengths:* Trfe I, 32 μ (28-32, X=30); tita I, 44 μ (44-52, X=47); ta II, 43 μ (41-48, X=44); ti III, 21 μ (20-22, X=21); ta III, 55 μ (48-57, X=54; trfe IV, 29 μ (25-33, X=29); ge IV, 15 μ (13-15, X=14); tita IV, 47 μ (25-30, X=29). *Setation*: Legs I: cx 1T, trfe 1T+1S+1 plumose, ge 4T, tita 13T+7S; legs II: cx 1T, trfe 3T, ge 3T, ti 4T+1S, ta 6T+1S; legs III: cx 1T, trfe 2T, ge 2T, ti 4T+1S, ta 6T; legs IV: cx 1T, trfe 2T, ge 1T, tita 6T.

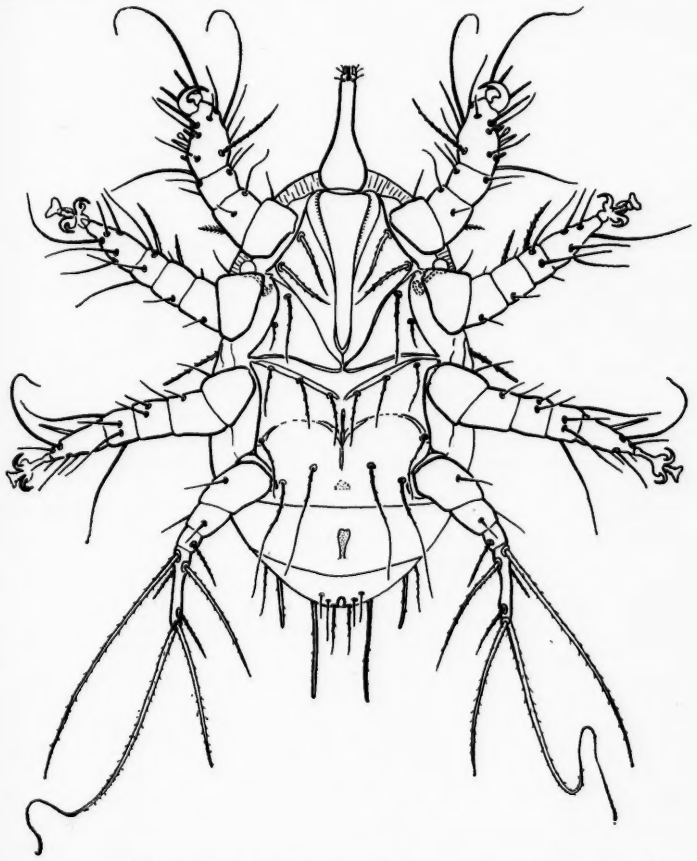

Fig. 2. *Nasutiscutacarus anthrenae*, new species. Ventral aspect of holotype female.

Tibiotarsus I not wider than remaining segments of leg, irregularly rectangulate, none of lateral sense clubs conico-acuminate, dorsal seta of tarsus II immediately anterodistad of sensory peg stout and spinelike, at least twice as wide basally as remaining setae of segment; tibia and tarsus IV completely fused, line of fusion indistinct.

Distribution: Known only from the type locality.

Type material: Holotype female and seven female paratypes (numbers I-VIII) from Key Islands, Asia Archipelago, (Indonesia) 1900, Kühn, from mesosoma of *Nomia (Nomia) strigata* (Friese) (determined by Heinrich Friese).

Type repositories: Holotype and four paratypes (nos. I-IV) in the Snow Entomological Museum at The University of Kansas. One paratype (no. V) deposited in the U. S. National Museum, Washington, D. C., one paratype (no. VI) in the Zoologisches Institut, Universität Erlangen, Erlangen, W. Germany, one paratype (no. VII) in the British Museum (Natural History).

Nasutiscutacarus ampliatus, new species
(Fig. 3)

DIAGNOSIS. Easily separable from the single other known species of the genus by the following characteristics: larger size; body ovate; first hysterosomal tergum spade-shaped; dorsal setae I arising more than half their own length anterior to laterals I; external caudal setae about three-fourths length of internal caudals and similarly plumose, fifth laterals well separated from preceding two pairs; external presternals arising well posterior to apodemes III; tarsus II with dorsal seta normal, not spinose; trochantofemur IV with only one seta.

FEMALE. Length, 344 μ (329-344); width, 217 μ (217-254); distance between anterior sternocoxal condyles of coxae III, 151 μ (151-180); body distinctly ovate, widest in region of legs III.

GNATHOSOMA. Length, 118 μ (111-130); width at widest point, 37 μ (35-48).

PROPODOSOMA. *Dorsum:* Width between centers of internal pseudostigmatal sockets, 103 μ (102-119); peritremes ovoid, opening anteriorly from propodosomal "shoulders." *Venter:* Setae of sternum I and sternal internals II abundantly plumose, at least on one side; sternal externals II nude or nearly so; sternal internals I, 70 μ (68-84) in length, subequal in length to sternal externals I; sternal internals II, 79 μ (76-89) in length; sternal externals II only 15 μ (14-19) long.

HYSTEROSOMA. *Dorsum:* First dorsal segment spade-shaped; all enlarged setae completely nude (or with apical third sparsely spinulate), blunt or jagged at the tips; dorsals I, 69 μ long (69-70), widely separated, 77 μ apart (77-88), arising well over half their length anterior to laterals I; laterals I slightly longer than dorsals I; dorsals II subequal to dorsals I in size, distinctly mesad of dorsals III, only 108 μ (108-117) apart; dorsals III, 74 μ (74-91) long, widely separated, 154 μ (154-176) apart, laterals III nude, 19 μ long (19-30) (see *Variation* below), arising laterad (to antero-laterad) of dorsals by less than diameter of dorsal areolus; dorsals IV

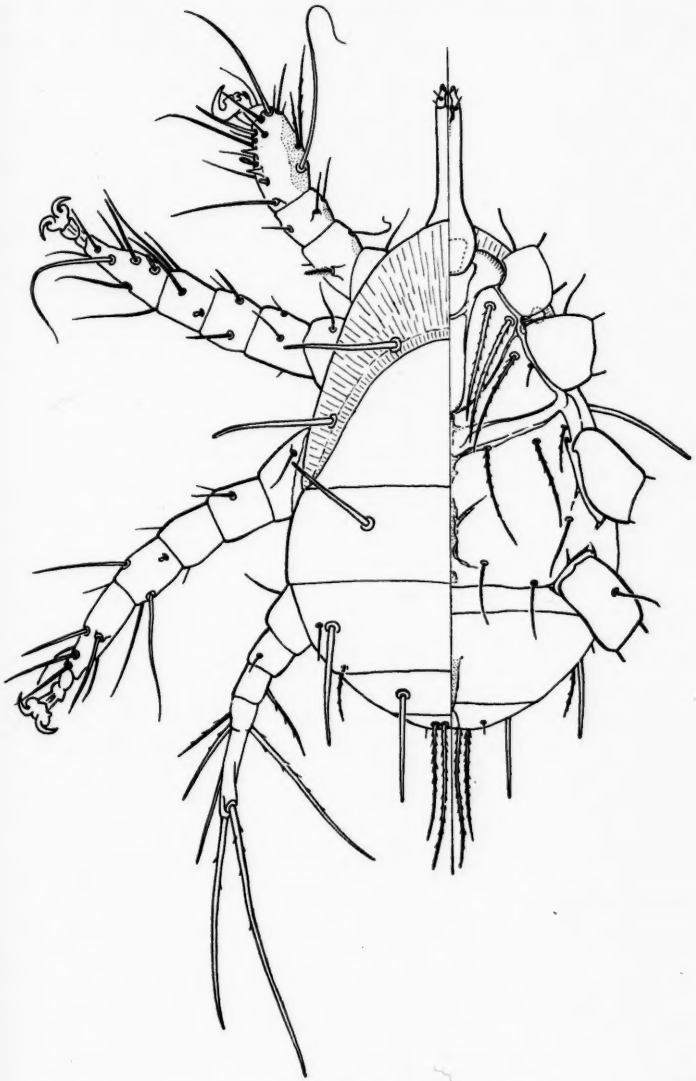

Fig. 3. *Nasutiscutacarus ampliatus*, new species. Partial dorsal and ventral aspects of holotype female.

closer to respective laterals than to each other, 68 μ (68-75) apart; laterals IV distinctly plumose and much longer than laterals III, length, 35 μ (35-72) (See *Variation* below), internal and external caudals with bases contiguous and well separated from laterals V; internal caudals heavily plumose to tips, 95 μ long (86-106); external caudals as plumose but shorter than internal caudals, length 83 μ (67-97); laterals V only 12 μ long (12-13), nude and bristlelike, separated from external caudals by slightly more than their own length. *Venter:* Presternal setae distinctly plumose, all others nude to weakly plumose; distance between anterior sternocoxal condyle of leg III and posterior margin of coxal foramen IV, 99 μ (97-108); apodemes III incomplete (or complete) medially, bearing internal presternals, these 85 μ (85-110) long; external presternals arising distinctly posterior to apodemes III, only slightly shorter than preceding setae; apodemes IV distinct only medially; second axillaries nude, distinctly shorter than presternals; external poststernals equal in length to internal poststernals (or distinctly longer than latter), not reaching posterior margin of body; internal poststernals arising distinctly anterior to external poststernals, reaching less than half way (to half way) to posterior margin of body; posterior margin of opisthosomal sternum entire.

LEGS. *Length:* Legs I, 138 μ (135-140); legs II, 188 μ (185-206); legs III, 231 μ (231-257); legs IV, 187 μ (187-220). *Width:* Legs I, 35 μ (33-37); legs II, 36 μ (36-42); legs III, 35 μ (35-39); legs IV, 22 μ (22-25). *Segment lengths:* Trfe I, 47 μ (46-48); tita I, 68 μ (68-71); ta II, 77 μ (75-81); ti III, 36 μ (36-44); ta III, 92 μ (90-99); trfe IV, 43 μ (42-47); ge IV, 22 μ (22-25); tita IV, 78 μ (78-95). *Setation:* Legs I: cx 1T, trfe 1T+1S+1 plumose, ge 4T, tita 13 T+8S (13T+7S); legs II: cx 1T, trfe 3T, ge 3T, ti 4T+1S, ta 6T+1S; legs III: cx 1T, trfe 2T, ge 2T, ti 4T+1S, ta 6T; legs IV: cx 1T, trfe 1T, ge 1T, tita 6T.

Tibiotarsus I not wider than remaining segments of leg, elliptoid; second lateral sensory club basad of sclerotized plate conico-acuminate, armed with an apical prickle, lateral sensory club immediately distad to sensory plate also conico-acuminate but lacking prickle; dorsal seta of tarsus II immediately anterodistad of sensory peg setiform, at its base not more than twice width of other setae of tarsus; tibia and tarsus IV fused but line of fusion well marked.

Variation: One specimen (paratype II) exhibits a great enlargement of some, but not all, of the body setae, notably sternal internals I and II, dorsals III, laterals III and IV, and both pairs of poststernals; such setae may be twice normal size. Setal conformation in this specimen is normal as are the body dimensions.

Distribution: Known only from the type localities.

Type material: Holotype female and one female paratype (no. I) from Casiguran, Province of Tayabas, Luzon, Philippine Islands, May, 1925, McGregor, from the pleural hairs of an unidentified species of *Nomia*. Two female paratypes (nos. II and III) from Mt. Makiling, Luzon, Philippine Islands, no date, Baker collector, from the mesosomal pubescence of *Nomia philippinensis* Ckll., (determined by T. D. A. Cockerell, 1919).

Type repositories: Holotype and two paratypes (nos. II and III) in the Snow Entomological Museum, The University of Kansas; remaining paratype in the U. S. National Museum, Washington, D. C.

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MILLIPEDS OF THE ORDER POLYDESMIDA FROM THE WESTERN STATES AND BAJA CALIFORNIA

H. F. LOOMIS
5355 S.W. 92 St., Miami 56, Florida

Among the millipeds collected by Dr. O. F. Cook in various localities in California and Baja California, from 1921 through 1929, are numbers of small specimens belonging to the order Polydesmida. These are of special interest as none seems to be of a species previously recorded. They are of five kinds, included in an established genus and two genera here presented as new. Another new genus, collected in Arizona by the writer, is described and notes on several recognized species, including new synonymy on one of them, also are given. Type specimens are deposited in U. S. National Museum.

Family POLYDESMIDAE

Genus *Brachydesmus* Heller

Brachydesmus bituberculatus new species

Three males (1 the type) and 2 females, Altamont Pass, above Niles, Calif., Dec. 1, 1926, O. F. Cook.

Diagnosis: Apparently most closely related to *B. yosemitensis* Causey, as indicated by the form of the gonopods and the setose anal valves, but of considerably smaller size and with specializations of the male legs and sterna that are not credited to that species.

Description: Length from 5.5 to 7 mm., largest specimen a male.

Head densely beset with quite uniform short setae over the entire surface; vertex with a faint median sulcus.

Segments 1 to 5 as shown in Fig. 1; all segments except the first with three transverse rows of seta-bearing tubercles, the two anterior rows separated by a distinct depression and with tubercles larger than those of the last row; setae of rows 1 and 2 curving upward and forward, those of

row 3 directed obliquely backward; tubercles of segment 18 reduced in size and those of the last segment represented only by small granules; pore calluses sharply set off and very convex with pores opening outward. Anal valves each with 20 to 30 long setae scattered over surface.

Gonopods as shown in Fig. 2.

Male legs, after first two pairs, with second joint swollen, the third pair of legs with joint 3 much more swollen than joint 2; anterior sternum of segment 10 with two small triangular lobes, the posterior sternum with two long conical tubercles projecting back from the margin (Fig. 3).

Family VANHOEFFENIIDAE

Use of this family name is known to be partially incorrect as it covers numbers of diverse genera unquestionably separating into several distinct families to one of which it may be applicable unless the included genera are found to fit in the much older family Dalodesmidae Cook 1896, as Jeekel (Beaufortia, vol. 51, p. 78, 1956) has suggested may be the case. Until the various generic groups now included under the Vanhoeffeniidae can be studied intensively, and their family limitations shown, it seems best to continue this name.

In the Checklist of the Millipeds of North America (U. S. National Museum Bull. 212, p. 77, 1958), Chamberlain and Hoffman apparently misunderstood Jeekel's remarks in the above paper as he showed that the genus *Gnomeskelus* Attems is a junior synonym of *Vanhoeffenia* Attems, not the reverse, and that the family founded on the latter genus has page priority over Sphaeriotrichopidae Attems.

In correspondence, R. L. Hoffman has expressed the belief, in which the writer concurs, that in addition to the genera herein described as belonging to this family group, *Antriadesmus* Loomis, *Speodesmus* Loomis, *Speorthus* Chamberlin and *Tidesmus* Chamberlin also should be included.

Harpogonopus new genus

Type: Harpogonopus confluentus n. gen.

Diagnosis: Readily distinguished by the large size; the confluent, convex, seta-bearing tubercles of the dorsal surface, in four transverse rows; and the very distinctive gonopods.

Description: Body larger than in other members of the American family group, slightly attenuated in front; males conspicuously flatter than females but with dorsal surface of keels more convex and the dorsal tubercles slightly smaller; dorsal setae of both sexes short and clavate.

Head entirely setose, setae of the front area slightly longer than elsewhere; vertex deeply sulcate at middle; antennae long, slender, geniculate at joint 4.

Segment 1 broadly rounded in front, the posterior sides directed caudomesally to the forwardly emarginate median portion; entire margin bordered with seta-bearing tubercles, additional ones scattered over the inner surface. Segment 2 slightly wider than segment 3 in the male, the two subequal in female; body widening gradually from segment 3 to

segment 14 or 15, especially in male; segments with four transverse rows of broad, strongly convex, fully or nearly confluent, shining, seta-tipped tubercles extending across both dorsum and keels, usually 10 to 12 tubercles in each row; from segment 4 or 5 backward there is a depression, more prominent in male, between second and third row of tubercles; lateral keels with free margins distinctly rimmed, the outer margin with three seta-tipped teeth more prominent on posterior half of body; posterior corners exceeding the back margin from segment 9 or 10 caudad to segment 19 where they are very small, lacking a keel in front of them; pores on usual segments opening obliquely outward and upward from rather small calluses which are wholly dorsal and contained within the raised outer rim; preanal scale large, triangular.

Gonopods with a large subhemispherical basal joint mesally enclosing a smaller heavy joint from the cephalo-mesal side of which a longer slender arm arises and terminates in three slender curved divisions of which one supports a much shorter, somewhat tongue-like element at base.

Male legs, after the second pair, heavier than in female, joint 2 especially enlarged.

Harpogonopus confluentus new species

Two males (1 the type) and several females, Cottonwood Creek, 45 miles east of San Diego, California, Jan. 22, 1921; 1 male, several females, Hodges Lake Dam, San Diego Co., Calif., Dec. 4, 1927; 3 females, Fallbrook, above Temecula, Calif., Apr. 3, 1929; 2 males, 3 females, 14 to 20 miles north of Ensenada, Baja Calif., Jan. 7, 1925; all specimens collected by O. F. Cook.

Description: Body 17 to 20 mm. long and up to 2.6 mm. wide; color in alcohol light brown.

Head described under genus; antennae with joints 1, 4 and 5 increasing in length, the latter somewhat shorter than subequal joints 2, 3 and 6, of which 6 is slightly thicker than any other joint .

Segment 1 with 18 to 20 seta-tipped tubercles along front margin and 12 to 16 near back margin, numerous others scattered over inner surface, the tubercles smaller and less distinct than those on other segments; outer angle on each side margined with a raised rim inside of which the surface is noticeably depressed. Segment 2 with keels produced forward as are those to segment 6 in decreasing amount, with those of segment 7 at a right angle to body. From segment 2 backward tubercles of first three rows, especially on keels, larger than of row 4, and on anterior segments those of first three rows less evenly arranged than further back; tubercles of female larger than those of male and completely confluent, each tubercle rising sharply from its neighbor; in the male the tubercles are smaller and separated by narrow spaces; free margins of keels with a strong raised rim, highest at anterior corner within which the surface is depressed, the back rim continuing across posterior margin of dorsum as well; produced posterior corners of keels largest at segment 16, decreasing somewhat on next two segments but very tiny on segment 19; pore calluses dorsal, set

within outer rim, rather inconspicuous and inflated only along mesal side, the pore opening from a flattened face. Last segment with four rows of setae rising from tiny granules; segment ending in a short mucro surpassing valves and terminating with 4 long setae; preanal scale large, triangular, about as long as sharply raised margins of valves.

Gonopods as shown in Figs. 4 and 5.

Oodedesmus new genus

Type: Oodedesmus variabilis n. sp.

Diagnosis: The medium size of the body; rounded corners on many keels, especially those on segments 2 to 7 or 8; and the strongly curved elements of the long outer joint of each gonopod, distinguish the genus.

Description: Body of medium size, Polydesmus-like in appearance but lacking the typical polygonal areas, and showing considerable variation in several of the structural features.

Head finely setose except on posterior half of vertex which is glabrous and evenly convex with a short indistinct median sulcus; antennae rather short and stout.

Segment 1 oval in outline; encircled by a submarginal series of erect clavate setae, with others scattered over inner surface and rising from it or from very small granules. Segments 2 and 3 with sides directed forward somewhat; segments 2 to 6 with three transverse rows of short thick setae on indistinct conic tubercles or rising from surface, apparently depending on locality from which collected. Succeeding segments with four rows of similar setae, rows 2 and 3 separated by a short more or less distinct sulcus terminating at keels; lateral keels narrow, outer margin on segments 2 to 4 thinner than on keels thereafter whose sides descend obliquely downward and inward directly from outer limit; free margins with raised rim, the outer margin smooth or with 2 or 3 variable teeth, each bearing a seta; poreless keels with anterior and usually posterior corners rounded; poriferous keels with posterior corners slightly if at all produced beyond back margin of segments on anterior three-quarters of body but projecting more strongly from segments 15 to 18; pores opening outward. Last segment ending in a short conic apex; anal valves evenly but moderately inflated, with thin raised margins; preanal scale large, triangular, with a long seta each side near apex.

Gonopods with large basal joint from mesoventral side of which the outer joint projects and is composed of a slender mesal branch, a stouter anterior one, and a third with a foliar element and two slender curved arms.

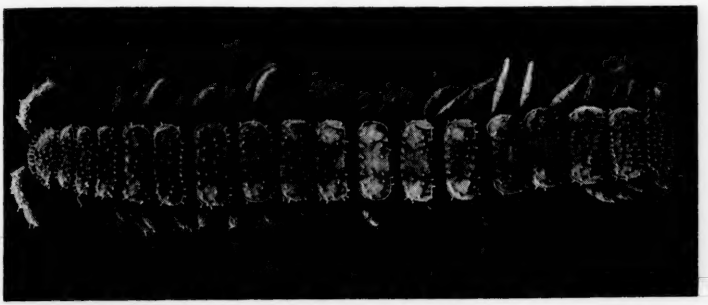
Male legs, after second pair, larger than those of female, joint 2 especially swollen.

Oodedesmus variabilis new species

Collected in Arizona by H. F. Loomis, 2 males (1 the type), a female and 1 young, Fish Creek, Jan. 21, 1923; a female, same locality, Feb. 1924; a male and 1 young, Baboquivari Mts., Nov. 21, 1923; several males and females, between Miami and Superior, Mar. 1, 1925; a male and 20 young of both sexes, Prescott, Aug. 9, 1930.

Description of holotype: Holotype shown in Plate I; living color pink to pinkish brown; dorsum nearly flat with clavate setae in quite definite rows arising directly from surface; length 11.7 mm, width 1.4 mm.

Head densely beset with short setae except on posterior half of vertex, a few longer setae on either side of anterior end of vertigial furrow which is faint; antennae rather stout, joint 1 shortest, joints 4 and 5 subequal and next in length, followed by subequal joints 2 and 6, the latter thickest of all, joint 3 slightly longest.



Oodedesmus variabilis, holotype male, 8.6X natural size.

Segment 1 oval, the outer limits opposite middle of segment and broadly rounded, median surface with 18 to 22 erect clavate setae scattered between an anterior row of 16 setae and a posterior one of 12. Segments 2 to 6 with three more or less definite transverse rows of 10 to 12 setae; ensuing segments with four sometimes indefinite rows of 8 to 11 setae although generally 10; surface of segments nearly smooth but with a faint depression between second and third row of setae on posterior end of body between keels. Segments 2 to 4 with keels slightly produced forward, outer margins a little thinner than those of succeeding keels which have margins thickened and lower sides descending directly from them mesoventrally; segments 2 to 14 with anterior and posterior corners of keels rounded, especially the poreless ones; posterior corners of segments 15 and 16 more angular, with those of segments 17 and 18 produced slightly beyond margin; those of segment 19 minute; outer margin of keels of segments 2 to 18 with a strong raised rim, with two faint, blunt teeth on segments 2 to 4 that are lacking thereafter but three marginal setae usually present; keels strongly convex above, rising above middle of dorsum; pore calluses not sharply indicated from above but in lateral view thicker than poreless keels, the pores normal in sequence, opening outward from near posterior corner. Last segment with four rows containing 8, 6, 4, 4 setae respectively, with four terminal ones in short, produced apex; anal valves broad and slightly convex, with two setae on either side near margin which is thinly raised; preanal scale large, triangular, apex sharply rounded with a long setae on each side.

Gonopods as shown in Figs. 6 and 7.

Sternum of segment 7 of male broad and thin between the legs, its front face excavated slightly on either side for the partial reception of the gonopods.

Although males from all localities have similar gonopods, those from other than the type locality show differences in several other features as follows: Joint 3 of antennae equals but does not exceed joint 6 in length and joint 2 is slightly shorter; the clavate dorsal setae usually are borne on small but evident granules or tubercles; the lateral keels behind segment 7 or 8 have their posterior corners more angular or even definitely produced; outer margin of keels not as thick as in males from type locality and usually with two or three marginal teeth; surface of keels of males from Miami-Superior not convex, the keels deflexed as in females. All females generally more convex than the males; surface of keels never convex but continuing descent of dorsum, their outer margins considerably below level of middorsum. Specimens varying in length from 9 to 14 mm. with males usually shorter than females.

Phreatodesmus new genus

Type: Phreatodesmus torreyanus n. sp.

Diagnosis: The small size of body and thickened outer margin of segment 2 of male, with a pronounced concavity on the under side, are distinctive characters supplementing those shown by the gonopods.

Description: Body small and slender, less than 10 mm. long and about one-tenth as wide; composed of 20 segments with normal pore formula; prozonites not greatly exposed.

Head setose except adjacent to segment 1; vertex sometimes without median furrow evident; antennae rather short and stout.

Segment 1 sublenticular, encircled by a marginal row of erect clavate setae with similar ones scattered over inner surface. Segment 2 of male with outer margin of each keel thickened, the ventral surface having a large concavity; keels of this and the next segment directed forward moderately; surface of segments 2 to 6 with three transverse rows of clavate setae on more or less conspicuous small tubercles, the segments thereafter with four such rows; dorsum with a definite transverse sulcus between keels separating rows 2 and 3; keels from segment 2 backward with a narrow raised rim, the posterior corners rounded or, at most, moderately produced beyond posterior margin; pores opening obliquely upward or outward from a small callus. Segment 19 with lateral keels greatly reduced, indicated only by a small poriferous projection on each side. Last segment slightly exceeding valves and crossed by three or four rows of setae in addition to the usual four terminal ones; anal valves slightly inflated with thin raised margins; preanal scale large, triangular, a seta on each side near apex.

Gonopods with basal joint large, mesally excavated and containing base of outer joint continued as a large, erect, flattened, posterior blade and an anterior, slender, sickle-like branch, longer than third branch which is shorter, more erect, and composed of two or three divisions .

Male legs, after second pair, larger than those of female, second joint

most enlarged. Segments behind gonopods with sterna smooth or with one or both bearing a small tubercle near each leg.

Phreatodesmus torreyanus new species

Four males (1 the type), 18 females and young, Torrey Pines, above La Jolla, Calif., Nov. 29, 1925, O. F. Cook; 2 males, 1 female, same locality, Nov. 1, 1925, "Hardy"; 1 male, Temescal Canyon Road, near Corona, Calif., Nov. 29, 1927, O. F. Cook; 1 male, young female, 14½ miles north of Ensenada, Baja Calif., Jan. 7, 1925, O. F. Cook.

Description: Body 5 to 7 mm. long and .5 to .7 mm. wide; males smaller than females with keels nearly the same, seldom inflated above; color in alcohol light brown.

Head setiferous except near segment 1, setae longest in front and shortest on vertex which has a sharply impressed median sulcus on posterior half; antennae as shown in Fig. 8.

Segment 1 sublenticular in outline, front margin broadly rounded; lateral angles opposite middle of segment rounded, with a raised rim; margin behind each angle straight, extending caudomesally to posterior median margin which is straight, surface with anterior row of about 16 small seta-bearing tubercles, a posterior row of 10 to 12 similar ones and two irregular intervening rows of about six or seven tubercles or granules.

Segments 2 to 6 with three transverse rows of seta-bearing tubercles extending onto keels, eight tubercles usually in each row but one or two others sometimes present; segments 7 to 19 with four similar rows, eight to ten tubercles in first and last rows, six in second and eight in third row where they are most conspicuous; transverse impression deep between rows 2 and 3, terminating at beginning of keels. Segment 2 of male with each keel thicker than in female, ventral surface with a sharply concave depression on anterior half; anterior and posterior corners rounded but latter acutely angular in female; outer margin smooth, without definite teeth; from segment 3 backward lateral keels project outward slightly above lower sides, usually being rather thin except at pore callus which is a moderately small oval thickening occupying less than the posterior half of margin; pores large, opening outward, upward and backward; posterior angles of keels of both sexes usually acute, very slightly produced on poreless ones, a little more so on those with pores but even on segments 17 and 18 corners not greatly developed and very small on segment 19; keels from segment 2 backward with a raised rim along all free margins, the outer margin of keels after segment 2 with two setiferous teeth in front of the posterior angle, the teeth less evident on poriferous keels; keels slightly deflexed, usually continuous with dorsum but in a male from type locality they are inflated above with the outer margin considerably thickened and the posterior corners are rounded or but slightly angular to segment 14. Last segment about as long as the penultimate, the short conical apex not deflexed; surface with four rows of setae containing 8, 6, 4, and 4 setae respectively, plus four apical ones; anal valves slightly convex, each with two long setae removed from the thin raised margin.

Gonopods as shown in Figs. 9 to 11.

Phreatodesmus cooki new species

Mature male (type), 9 or 10 young, Clear Creek, Tehachepi Pass, Kern Co., Calif., Feb. 15, 1929, and 1 male, Woodford, near Tehachepi, Calif., Jan. 8, 1928, O. F. Cook.

Diagnosis: A slightly larger and flatter species than the other two, with concavity on under side of segment 2 larger; surface of keels more strongly convex; dorsum with less distinct tubercles; and gonopods distinctive.

Description: Body about 8 mm. long, .7 mm. wide; nearly flat above, the convex surface of keels of males higher than intervening dorsum and with a few scattered setae.

Head setose as in other species; furrow of vertex very faint; antennae quite short and crassate, joints 2, 3 and 6 subequal in length, the latter thickest but scarcely more so than joint 5.

Segment 1 with shape and dorsal setae as in *P. torreyanus* but with tubercles fainter.

Segments 2 to 6 with anterior row of 12 to 14 setae, a middle row of approximately 12 and a posterior row of 10 to 12 setae; from segment 7 to 19 there are four rows, the first with about 10 setae, second and third rows with six to eight setae and these not extending onto keels, last row with eight to 12 setae, the larger number on posterior segments where they extend onto the back margin of the keels. Segment 2 of males with keels not quite as thick as in *P. torreyanus* but with ventral concavity larger, occupying most of the surface; outer margin of each keel rounded, devoid of teeth but with three setae; keels thereafter with two weak seta-bearing teeth or with the setae only, in advance of posterior corner; anterior and posterior corners of segment 2 rounded as they are through segment 9, after which posterior corners first are angular, becoming slightly produced on segments 15 to 18, but very small and inconspicuous on segment 19; keels narrow and thickened, the free margins with a fine raised rim least evident on the outer margin; sides descending directly from outer margin; pore calluses small and but little inflated, inconspicuous from above, the pores opening outward from an almost vertical face. Last segment, anal valves and preanal scale essentially as in *P. torreyanus*.

Gonopods as shown in Fig. 12.

Males with anterior sternum of segments 9 or 10 to 16 or 17 with a small but distinct transverse tubercle, rounded at apex, adjacent to each leg.

Phreatodesmus dentatus new species

Two males (1 the type) and 11 females or young, Cajon Pass, 7 miles west of Cajon, San Bernardino Co., Calif., Feb. 14, 1929, O. F. Cook.

Diagnosis: Projection of the keels and form of the gonopods indicate close relationship with *P. torreyanus*, but the species is easily separated from it and others by the strongly dentate keels and more definitely tuberculate dorsum.

Description: Body about 5 or 6 mm. long and .6 to .7 mm. wide; dorsum of both sexes convex, the males slightly less so as the keels are somewhat

inflated; keels descending outwardly, strongly projecting beyond the lower sides; outer margins thin in both sexes.

Head setose as in other species; median sulcus of vertex faint or lacking; antennae somewhat more slender than in other species, joint 6 decidedly thicker than joint 5 and equalling or exceeding in length joint 2 or 3 which are subequal.

Segment 1 sublenticular with setae arranged as in *P. torreyanus* but on more distinct tubercles; each outer angle rounded and with a faint rim. Dorsum of succeeding segments with short, strongly clavate setae borne on small tubercles more distinct than in the other species and arranged as follows—segments 2 to 6 with three rows of seta-bearing tubercles extending onto the keels, eight to ten in each row; segments 7 to 19 with four similar rows; transverse depression deep and quite sharply defined, separating rows 2 and 3 between bases of keels.

Segment 2 of male with each outer margin but little thicker than on ensuing segments or than in females; ventral concavity well defined, about as large as in *P. cooki*; segments 2 and 3 of both sexes produced forward slightly on each side; outer margin of keels of segment 2, and sometimes of segment 3, with five small dentations, the keels thereafter with two strong, angular, outwardly elevated, seta-tipped teeth in advance of the seta-tipped posterior corner; on poriferous segments a fourth seta projects from beneath the pore callus; posterior corners of keels from segment 2 or 3 backward projecting beyond the caudal margin, those at back end of body little more produced than those at middle; keels of segment 19 greatly reduced, the posterior angles small but larger than in *P. torreyanus* or *P. cooki*; pore calluses moderately swollen and occupying most of posterior half of margin, the pores opening outward, upward and backward, somewhat visible from above. Last segment with setae in three poorly defined rows at best, eight in first row, six in second and four in third row, the usual four setae in the slightly deflexted apex; anal valves and preanal scale as in the other species.

Gonopods as shown in Fig. 13.

Male legs, after second pair, somewhat heavier than those of female but not strikingly so; second joint the most enlarged; sterna of segments 9 to 14 or 15 with a small transverse tubercle on either side near each leg.

Phreatodesmus hastingsus (Chamberlin), new synonymy

Brachydesmus hastingsus Chamberlin, Bull. Univ. Utah, 31: no. 11, p. 27, pl. 5, figs. 48-49, 1941.

Reference to the description and illustrations of this species provides characters to disprove the correctness of locating it in the genus *Brachydesmus* and further indicates that it is not a member of the family to which that genus belongs. The clavate setae rising from dorsal tubercles and the outer margin of the keels, and their arrangement in four transverse rows on the main body segments, associate the species with certain vanhoeffeniids rather than any polydesmids and this association is more emphatically brought out by the structure of the gonopods, as shown in

the illustrations. On the basis of Chamberlin's Fig. 49, which shows an enlarged basal joint supporting 3 slender elements and a thin, plate-like one, the species is referred to the present genus, where it may remain, with some doubt, until examination of the type or a topotype male can clarify its position.

Speorthus tuganbius Chamberlin

Speorthus tuganbius Chamberlin, Ent. News, 63: 11-12, 1952.

Many years ago, H. S. Barber, Entomologist in the U. S. National Museum, sent me a vial containing several dozen small, badly broken, millipeds and a label marked only "11243 Bishop." Recently I asked Dr. Ralph E. Crabill, Jr., in charge of the myriapod collections of that museum, if he could throw any light on the meaning of the label. He was able to do so, reporting that "The Bishop catalog number **** 11243 refers to a collection of millipeds made at Carlsbad Cavern, **** Carlsbad, New Mexico, April 24, 1924. The collectors are O. G. Babcock and a Bailey, first initials not given. This unqualified Bailey is almost certainly Vernon Bailey, who wrote the book in 1928 on these caverns. In addition there is a note to the effect that the creatures were found about 50 yards from the entrance of the cavern on moist soil." Following receipt of this information the specimens were identified as the above species when it was observed that the data given by Dr. Crabill coincide closely with those Chamberlin published in describing the species. It is evident that part of the original collection made in Carlsbad Cavern was sent to him while the major portion, containing both sexes, went to the National Museum and sometime later was sent to me. Thus the specimens I received are essentially syntypes and of special importance. A supplementary description of the species is here given.

Description: Segment 1 with a tiny tooth on anterior margin just in advance of each outer angle; next three segments with three distinct teeth on outer margin of each keel in front of the larger posterior corner; from segment 5 backward there are four or five such teeth in advance of the corner; from segment 2 to 19 the posterior corners of all keels are sharply angular and produced beyond the posterior margin which has two or three sharply projecting, triangular teeth on each side, the largest tooth nearest

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Figs. 1 to 3. *Brachydesmus bituberculatus* n. sp. 1, half of head and dorsum of first 5 segments; 2, left gonopod, lateral view; 3, sterna and base of legs of segment 10 of male. Figs. 4 and 5. *Harpogonopus confluentus* n. sp. 4, right gonopod, oblique downward anterior view; 5, apex of left gonopod, mesal view. Figs. 6 and 7. *Oodedesmus variabilis* n. sp. 6, right gonopod, anterior and slightly mesal view; 7, left gonopod, posterior view. Figs. 8 to 11. *Phreatodesmus torreyanus* n. sp. 8, antenna; 9, left gonopod, lateral view; 10, left gonopod, anterior view; 11, terminal joint of right gonopod more greatly magnified, anterior view. Fig. 12. *Phreatodesmus cooki* n. sp., right gonopod, anterior view. Fig. 13. *Phreatodesmus dentatus* n. sp., right gonopod with terminal joint extended, anterior view. Figs. 14 to 16. *Speorthus tuganbius* Chamberlin. 14, right gonopod, lateral view; 15, right gonopod, mesal view; 16, apex of left gonopod slightly more magnified, mesal view. Fig. 17. *Antriadesmus fragilis* Loomis, right gonopod showing the intercoxal sternite, anterior view, drawn by R. L. Hoffman.

Explanation of Figures on Opposite Page

keel. Dorsal setae rather slender, rising from tiny tubercles or granules; on anterior segments they are arranged in three definite rows but further back only in the first and last rows are they uniformly arranged, the intervening ones somewhat scattered, seldom forming three evident rows. Pore calluses small and not strongly inflated, occupying less than half of the outer margin of keel; pores opening obliquely upward. Legs long and slender, last joint longest; legs of male slightly heavier than in female, much like those of *Speodesmus echinourus* Loomis but lacking ventral granules in male.

Gonopods as shown in Figs. 14 to 16.

The obvious similarity of the gonopods of this species with those of *Speodesmus echinourus* may be noted and, although there are several quite striking structural differences between the two species, greater knowledge of them or possible undiscovered ones may require uniting all in a single genus.

Antriadesmus fragilis Loomis

Antriadesmus fragilis Loomis, Bull. Mus. Comp. Zool., 92: 408-10, 1943.

In 1958, Leslie Hubricht collected numerous topotype specimens of this milliped and sent them to R. L. Hoffman with the information that the species occurs only in White's Cave of the entire Mammoth Cave complex. Mr. Hoffman has sent me a drawing of the male gonopod reproduced here with his permission (fig. 17). As will be observed, the gonopod does not show close relationship with any of the other members of the group dealt with in this paper.

Chaetaspis albus Bollman

Chaetaspis albus Bollman, Ent. Amer., 3: 46, 1887.

While this species probably belongs in this family group, the gonopods never have been illustrated and its affinity with the other members awaits examination of these structures. Also, it can then be determined if *C. ohionis* Causey, originally reported, with illustration of a gonopod, as *C. albus* Bollman, by Williams and Hefner, Ohio St. Bull., 33: 110, 1928, was assigned to the proper genus, as Dr. Causey indicated was doubtful.

Genus *Tidesmus* Chamberlin

Tidesmus Chamberlin, Proc. Biol. Soc. Wash., 56: 35-36, 1943.

The gonopods of the genotype, *T. episcopus*, appear quite distinctive and, when considered in conjunction with the several body characters mentioned, indicate some relationship with *Phreatodesmus*, among the North American genera. Reference to the illustration of *T. hubbsi* Chamberlin (*loc. cit.*) casts doubt on its being congeneric with *T. episcopus* as in no genus of the vanhoeffeniid aggregation known to the writer do the posterior corners of segment 19 equal or exceed those of segment 18, instead they are usually very much smaller. Examination of a topotype male of *T. hubbsi* is needed to determine its generic position.

A NEW SPECIES OF *NOTONECTA* FROM THE FLORISSANT (Hemiptera, Notonectidae)

DAVID R. LAUCK
Chicago Academy of Sciences

Kirkaldy (1904) lists nine fossils that were described as species of *Notonecta*. Of these nine, *N. jubata*, *N. comata*, and *N. deichmülleri*, all described by Schlechtendal (1894) from Europe, are probably the only species more closely related to *Notonecta* than to other notonectid genera. These three all differ from the modern *Notonecta* by their short, thickened forelegs.

Since Kirkaldy's list, two additional names of fossil forms have been added to the genus *Notonecta*. Pierce (1948) described *Notonecta (Paranecta) badia* from a series of several nearly whole insects and numerous fragments from an asphalt field (Pleistocene) at McKittrick, California. Jordan (1935) described *Notonecta rotti* from coal deposits (Oligocene) at Rott im Siebengebirge, Germany.

In North America, other than *Notonecta badia* Pierce, only a single specimen from the Florissant, *Notonecta emersoni* Scudder, 1890, has been assigned to the above genus. It seems rather unlikely, as already mentioned by Kirkaldy (1904) and Hungerford (1934), that this small slender species belongs to the genus *Notonecta*. Thus the following description probably represents the only known member of the genus *Notonecta* from the Florissant of Colorado (Oligocene).

Notonecta binuda new species (Fig. 1)

Size: Total length unknown due to vague and blurred imprint of head, however approximately 12 mm. long; length caudad of metacoxae, 4.1 mm.; width at base of metacoxae, 3.8 mm; right metafemur, 3.3 mm. long.

Structural characteristics: Head not discernible. Forelegs normal, not short and thickened; mesotrochanters rounded; metafemora with numerous slender setae, short spines, and submarginal row of stout spines on ventral surface. Ventral keel of 4th abdominal sternite apparently bare; keel of 5th sternite broad and distinctly bare, nearly as long as keel of 4th sternite; keel of 6th sternite covered with hairs.

Comparative notes: N. binuda n. sp. resembles *N. impressa* Fieber[1] in that the ventral keel of both the 4th and 5th abdominal sternites is bare; however, the keel of the 6th sternite of *N. impressa* is also bare and the keel of the 4th sternite is distinctly broader than that of the 5th segment, while in *N. binuda* n. sp. the keel of the 6th sternite is densely set with hairs and the keel of the 5th sternite is as broad as, if not broader than, that of the 4th.[2] The chaetotaxy of the metafemur of *N. binuda* n. sp.

[1] Also similar to *N. montezuma* Kirkaldy if it is to be considered a valid species.
[2] Although the keel of the 4th abdominal sternite appears broader, this may be only a distortion from fossilization.

is very similar to *N. insulata* Kirby and *N. kirbyi* Hung., but may be distinguished from these two species by having the keel of the 5th sternite bare and some of the setae of the metafemora more slender and longer.

N. binuda n. sp. appears to be intermediate between *N. insulata* and *N. impressa*, but differs markedly from these by the much smaller size, which more closely approaches the size of *N. undulata* and other members of the subgenus *Paranecta*.

Fig. 1. Imprint of *Notonecta binuda* n. sp. (4X) (Photographed by Zenith Noon).

Type: Known only from the holotype, presumably a male, as indicated by the genital capsule which is represented by a dark, nearly circular spot at the tip of the abdomen. Both sides of the fossil are present. The type will be placed in the Francis Huntington Snow Museum, Department of Entomology, The University of Kansas, Lawrence, Kansas.

Locality: The specimen was one of several fossils of insects in a case at the University of Illinois. The case was labelled: "Florissant Insects. Horizon: Miocene shales of Florissant. Locality: Florissant, Colorado. . . . Collected and prepared by G. F. Sternberg and Son." The fossil itself had the label: "Hemiptera. Gerridae. Water Strider." The age of these shales is believed to be about 30 million years.

Etymology. *N. binuda* n. sp. derives its name from the bare 4th and 5th abdominal sternites.

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I wish to thank Professors L. E. Chadwick and W. V. Balduf, University of Illinois, for their helpful suggestions.

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THE GENUS *TEPHRITIS* LATREILLE IN THE NEARCTIC REGION NORTH OF MEXICO: DESCRIPTIONS OF FOUR NEW SPECIES AND NOTES ON OTHERS (Diptera: Tephritidae)

RICHARD H. FOOTE
Entomology Research Division, ARS, U.S. Department of Agriculture, Washington, D.C.

A revision of the genus *Tephritis* Latreille in the Nearctic region north of Mexico was presented by Quisenberry (1951) to place generically a number of species long incorrectly associated with the name *Tephritis*, and to bring up to date and summarize for the first time the then scattered knowledge of the genus. The inclusion of notes on species previously assigned to *Tephritis* makes it one of the most important publications ever to appear concerning the family in this geographic region. During the past several years I have discovered four new species of *Tephritis* and have accumulated a number of references, records, and notes on previously known species. This information is presented here in order to bring the excellent work of Quisenberry up to date.

The key presented by Quisenberry has been completely recast to include the new species and to record more recent observations on variation within species already known. In the synonymy for each species reference to the original description is given first; all subsequent synonymical references are those *not* already recorded by Quisenberry. In the distribution records "t.l." indicates the type locality. New distribution records (i.e., those not previously published) indicate for each state the localities separated by commas; the inclusive dates of capture, regardless of locality or year; and the inclusive years in which the dates for each state occurred. None of the new localities, as far as known, repeats information presented in the sections on previously recorded distribution. All available data on hosts have been summarized in the present paper.

The following individuals have loaned specimens for this study: Miss Marian Adachi, University of Arizona, Tucson; Paul H. Arnaud, Jr., California Academy of Sciences, San Francisco; R. S. Beal, Jr., Arizona State University, Tempe; F. L. Blanc, California Department of Agriculture, Sacramento; W. L. Brown, Jr., Museum of Comparative Zoology, Cambridge, Massachusetts; G. W. Byers, University of Kansas, Lawrence; R. R. Dreisbach, Midland, Michigan; B. A. Foote, University of Idaho, Moscow; R. C. Froeschner, Montana State College, Bozeman; H. J. Grant, Jr., Academy of Natural Sciences, Philadelphia, Pennsylvania; G. F. Knowlton, Utah State University, Logan; A. T. McClay, University of California, Davis; H. Rodeck, University of Colorado Museum, Boulder; C. W. Sabrosky, U. S. Department of Agriculture, Washington, D. C.; G. Wallace, Carnegie Museum, Pittsburgh, Pennsylvania; and H. V. Weems, Jr., Florida State Plant Board, Gainesville.

Genus *Tephritis* Latreille

Tephritis Latreille, 1804, Dict. d'Hist. Nat., Deterville, 24:196. Type-species: *Musca arnicae* Linnaeus, by designation of Cresson, 1914, Ent. News 25:275.

The genus *Tephritis* belongs to the tribe Tephritini of the subfamily Tephritinae, as set forth in a key to supergeneric categories by Hering (1947). An extensive generic diagnosis of *Tephritis* is presented by Quisenberry. The species inhabiting the Nearctic region north of Mexico resemble in one way or another those of all seven Nearctic tephritine genera: *Oxyna* Robineau-Desvoidy, *Euaresta* Loew, *Paroxyna* Hendel, *Trupanea* Guettard, *Dyseuaresta* Hendel, *Euarestoides* Benjamin, and *Neotephritis* Hendel. All these genera have wing patterns that are reticulate (i.e., rounded hyaline spots on a dark field) or have a dark pre-apical starlike mark on a hyaline field with dark rays to the margins, or have a combination of both types of patterns. *Tephritis* is distinguished from all genera except *Paroxyna* and *Euaresta* by the possession of two pairs of lower fronto-orbitals, and from *Trupanea* and *Dyseuaresta* by the presence of two pairs of scutellars. Species of *Paroxyna* have very narrow thoracic squamae, geniculate proboscides, and are rarely without a rounded hyaline spot in the stigma—characters never found in *Tephritis* in spite of the marked similarity of wing pattern in the two genera. All *Euaresta* species have some kind of hyaline stigmal marking, the fore femora of males are swollen, and the male terminalia have conspicuous striations around the anal region.

KEY TO *Tephritis* SPECIES OCCURRING IN THE NEARCTIC REGION NORTH OF MEXICO

1. Cells R, R_3, and 1st M_2 entirely dark except for small, ill-defined hyaline areas ..... 1. *opacipennis,* n. sp.
   Cells R, R_3, and 1st M_2 each with several large, well-defined hyaline spots 2
2. Uninterrupted hyaline area filling entire apex of cell R_5 and most of apex of cell R_3 ..... 2. *rufipennis* Doane

This hyaline area always interrupted by a dark ray lying upon vein R_{2+3} or vein R_{4+5}, or both 3

3. Thorax predominantly bright yellow pollinose; cell C without distinct brownish spots; pre-apical infuscated area entire and not broken by many small and confluent hyaline spots ..... 3. *subpura* (Johns.)

Combination of characters not as above 4

4. Pre-apical brown area of wing obscured by numerous round, confluent subhyaline spots; dark pattern in cell R_1 immediately posterior to stigma usually with at least one yellowish or hyaline spot (if no spot present, anterior arm of Y-shaped mark at wing apex broken or conspicuously narrower than posterior arm) 5

Pre-apical brown area usually with at most a few round, subhyaline spots, its appearance never obscured by these; dark pattern in cell R_1 immediately posterior to stigma unmarked; Y-shaped mark in wing apex never as above 6

5. Brown pattern extending to posterior wing margin along entire lengths of cells Cu_1 and 2nd A ..... 4. *californica* Doane

Brown pattern extending to posterior wing margin only in extreme apex of cell Cu_1 ..... 5. *arizonensis* Quis.

6. Dark band from stigma to vein r-m without small hyaline spots; wing pattern much as in *Trupanea*, with a distinct star-like pre-apical mark; almost no dark markings in proximal half of cell 1st M_2; basal posterior quarter of wing disc with few dark markings 7

Dark band from stigma to vein r-m and pre-apical star-like mark usually with hyaline spots; area of wing disc posterior to vein M_{1+2} with more extensive dark markings 8

7. Cell Cu_1 with a dark mark extending from vein $M_{3+}Cu_1$ to posterior wing margin ..... 6. *stigmatica* (Coq.)

Cell Cu_1 with a dark mark in extreme base and one lying along the length of vein $M_{3+}Cu_1$ ..... 7. *labecula* Foote

8. Dark brown of wing pattern extending to posterior margin along entire length of wing ..... 8. *signatipennis*, n. sp.

Cell 2nd A never dark at extreme margin 9

9. Dark pattern in cell 2nd M_2 never extending to posterior margin of that cell ..... 9. *angustipennis* (Lw.)

Dark pattern in cell 2nd M_2 always extending to posterior margin of that cell 10

10. Apical margin of second hyaline spot in cell R_1 never extending apicad beyond anterior extension of vein m 11

Apical margin of second hyaline spot in cell R_1 extending well beyond anterior extension of vein m 12

11. Vein $M_{3+}Cu_1$ broadly bordered with brown beyond its junction with vein m, at least in cell 2nd M_2 ..... 10. *webbi* Doane

Vein $M_{3+}Cu_1$ narrowly bordered with brown beyond its junction with vein m ..... 11. *pura* (Lw.)

12. At least three hyaline spots in cell R_1 beyond apex of stigma 13
Never more than two hyaline spots in cell R_1 beyond apex of stigma 14

13. Femora primarily yellow; if dark gray dusting present, never so heavy as to obscure yellow ground color ..... 12. *michiganensis* Quis.
Femora, especially those of hind legs, dark gray pollinose ..... 13. *ovatipennis*, n. sp.

14. Apex of cell R and base of cell R_5 hyaline; vein r-m surrounded by a hyaline area ..... 14. *candidipennis*, n. sp.
Apex of cell R and base of cell R_5 infuscated; vein r-m surrounded by an infuscated area ..... 15. *araneosa* (Coq.)

1. *Tephritis opacipennis*, new species
(Fig. 1)

MALE. Head in profile slightly higher than long; cheek 0.20 times as high as eye; parafrontal and parafacial regions very light yellow, lightly pollinose; face in profile almost parallel to vertical axis of head, not concave nor projecting anteriorly at oral margin; frons yellow; proportion of width at vertex to length from vertex to antennal bases as 7:10; face and lunule yellowish white, densely pollinose. Antenna yellow, about 0.5 times as long as face; third segment about 1.5 times as long as width at base; arista very dark brown except at extreme base, which is yellow. All head bristles light except ocellars and lower fronto-orbitals, which are dark brown.

Thorax ground color black; mesonotum, metanotum, pleural sclerites, and postscutellum densely dark gray pollinose without lighter markings; scutellum bearing a central yellowish spot seen most readily from behind; all bristles black; thorax covered with short, stout, blunt, yellowish setae. Halter dark basally, knob yellowish. Fore and hind legs entirely yellow; mid coxae dark basally, remainder of mid leg yellow. Wing (Fig. 1) mostly dark with the following hyaline areas: Almost all of cells 1st and 2nd C, except for a dark, submedian costal spot in latter; a rounded spot in cell R_1 immediately distad of stigma; one extending completely across cell R_1 just basad of level of vein m; in one specimen an extremely small spot halfway between latter and apex of vein R_1; a rounded spot in cell R_3 immediately distad of apex of cell R_1 and another almost at apex of cell R_3; a semicircular spot in distal end of cell R_5, not touching either vein R_{4+5} or vein M_{1+2}; four rounded spots in cell 2nd M_2, one near apex, one near junction of veins m and M_{1+2}, and two along posterior wing margin posterior to last-named spot; all of cell Cu_1 hyaline except length of vein $M_{3+4}Cu_1$, which is covered by a narrow dark area with an uneven posterior border, sometimes a small isolated dark spot in center of that cell; nearly all of cells C, 1st A, and 2nd A hyaline except for a small dark area lying upon junction of veins Cu_2 and 2nd A; cell 1st M_2 with faint indication of hyaline areas in distal third; stigma very long and narrow with vein R_1 straight rather than bowed, giving stigma a wedge-shaped appearance.

Abdomen concolorous with mesonotum, but terga in certain lights, especially when viewed from behind, with narrow, light colored posterior

borders and a submedian row of somewhat darker spots, ill-defined, on terga II, III, and IV.

FEMALE. Not known.

Material examined: Holotype, ♂, Cedar Pass, Modoc Co., Calif., 29.VI.1956 (Dahlsten). U. S. National Museum Type No. 64828. Paratypes (all Calif.): 1 ♂, Hay Lake, Lassen Nat'l. Park, 20.VI.1941 (Hurd) (Univ. Calif., Davis); 1 ♂, San Bernardino Mts., 11.IX.1944 (Timberlake) (Calif. Acad. Sci.).

Hosts: The paratype from San Bernardino Mts. was collected from *Chrysothamnus nauseosus*.

Discussion: The dark wing (Fig. 1) sets this species apart from all others in the entire tribe Tephritini in the Nearctic region north of Mexico. *Trupanea conjuncta* (Adams) has an unbroken dark area not entirely representative of *Trupanea*, another tephritine genus, but the proximal half of the wing of that species is much more extensively hyaline than in *opacipennis*, and the presence of a single pair of scutellars further distinguishes it.

2. *Tephritis rufipennis* Doane

Tephritis rufipennis Doane, 1899, Jour. New York Ent. Soc. 7:190. Aldrich, 1905, Smiths. Misc. Coll. 46(1444):612. Quisenberry, 1950, Jour. New York Ent. Soc. 58:11. Quisenberry, 1951, Jour. Kansas Ent. Soc. 24:60; pl. 1, fig. 4.

Previously recorded distribution.—California (t.l.): San Mateo.

New records.—CALIFORNIA: Solano Co.; 1.XI, 1946.

Host: Unknown.

Discussion: The wing of this distinctive species (Quisenberry, 1951, pl. 1, fig. 4) is reminiscent of species of *Oxyna* in having an almost continuous transverse hyaline band from the apex of the stigma to the posterior margin of cell 2nd M_2. The presence of two pairs of lower fronto-orbitals adequately distinguishes *Tephritis* from *Oxyna*, which has only one pair.

3. *Tephritis subpura* (Johnson)

Euaresta subpura Johnson, 1909, Psyche 16:114. Johnson, 1910, Ann. Rept. New Jersey State Mus., 1909:803.

Tephritis subpura: Quisenberry, 1950, Jour. New York Ent. Soc. 58:11. Quisenberry, 1951, Jour. Kansas Ent. Soc. 24:62; pl. 1, fig. 6. Foote, 1959, Bull. Brooklyn Ent. Soc. 54:16, 17.

Previously recorded distribution.—New Jersey: Wildwood (t.l.); Florida.

New records.—FLORIDA: Ft. Lauderdale, Homestead, 15 mi. s.w. of Malabar, 1 mi. w. of Malabar, Mayport, 2½ mi. n. of Narcoosee, Orlando, 7 mi. n.e. of Osteen, West Palm Beach; 25.IV to 28.V, 1931-1959. NEW YORK: Riverhead, Orient; 2.IX to 14.X, 1955. VIRGINIA: Warsaw; 26.VII, 1952.

Hosts: The type specimens were taken on sea burweed, *Xanthium echinatum*, at two localities in New Jersey, and Benjamin (1934) records

the species as reared from stems of *Baccharis glomeruliflora* in Florida. The Florida specimens listed in the "New localities" section above were taken on *Galactia* sp., myrtle, and from fruit fly traps in mango and guava.

4. *Tephritis californica* Doane

Tephritis californica Doane, 1899, Jour. New York Ent. Soc. 7:190. Aldrich, 1905, Smiths. Misc. Coll. 46(1444):611. Quisenberry, 1951, Jour. Kansas Ent. Soc. 24:64; pl. 1, fig. 9.

Previously recorded distribution.—California: Palo Alto (t.l.) and eight other localities.

New records.—CALIFORNIA: 42 localities throughout the state; I through XII, 1897-1956.

Hosts: Adults of *californica* have been collected from flowers of *Asclepias* sp. and *Baccharis pilularis*, and in a fruit fly trap in walnut. Two males sent for determination by Paul H. Arnaud, Jr., bear the label "apparently breeds in *Baccharis pilularis*."

5. *Tephritis arizonensis* Quisenberry

Tephritis arizonaensis Quisenberry, 1951, Jour. Kansas Ent. Soc. 24:62; pl. 1, fig. 1.

Previously recorded distribution.—Arizona: Tumicari Mts. (t.l.), Santa Rita Mts., and Tucson.

New records.—ARIZONA: Catalina Mts., 12 mi. s.w. of Elroy (Pinal Co.), Mesa, Scottsdale, Tanque Verde; 6.I to 27.XI, 1917-1959. CALIFORNIA: San Diego; "Apr." (no further data).

Hosts: The species has been collected from *Baccharis sarothroides* and *Baccharis* sp. Males and females were reared by Miss Marian Adachi from a terminal gall on *B. sarothroides* at Tucson in 1959.

6. *Tephritis stigmatica* (Coquillett)

Urellia stigmatica Coquillett, 1899, Jour. New York Ent. Soc. 7:266. Adams, 1904, Kansas Univ. Sci. Quart. 2:450. Aldrich, 1905, Smiths. Misc. Coll. 46(1444):614.

Tephritis stigmatica: Quisenberry, 1951, Jour. Kansas Ent. Soc. 24:64; pl. 1, fig. 11. Foote, 1959, Bull. Brooklyn Ent. Soc. 54:15, fig. 3.

Previously recorded distribution.—Arizona, California, Colorado (t.l.), Idaho, New Mexico, Oregon, Texas, Utah.

New records.—ARIZONA: Buckeye, Chiricahua Mts., Cooledge, Elroy, Tucson, Superior; 3.IV to 2.XI, 1928-1955. CALIFORNIA: 23 localities in the southern half of the state; 15.III to 30.IX, 1907-1958. IDAHO: Chilco, Golden Valley, Granite, Hansen, Lawyer's Canyon, Moscow, Squaw Creek, Stanley; 31.V to 19.VIII, 1909-1952. MONTANA: 11 mi. so. of Phillipsburg; II.VII, 1955. NEVADA: Harrison Pass, Ormsby Co.; 25.VI to 6.VII, 1902-1929. NEW MEXICO: Alamagordo, top of Las Vegas Range, 2½ mi. no. of Lordsburg, Springer; 2.IV to 10.VIII, 1902-1929. TEXAS: Dickinson, Sanderson; 9.V to VI, 1912-1929. UTAH: St. George; 18.IV, 1930. WASHINGTON: Blue Mts. (4,000 ft. alt.); 22.V, 1936.

Hosts: Specimens representing some of the new records listed above were collected from *Eriodictyon* sp. and *Gutierrezia lucida. Trupanea stigmatica* has been reared in southern California from *Senecio integerrimus* and *Senecio* sp.

Discussion: See discussion of *labecula* below.

7. *Tephritis labecula* Foote

Tephritis labecula Foote, 1959, Bull. Brooklyn Ent. Soc. 54:13; fig. 2.

Previously recorded distribution.—Utah: Grand Co. (t.l.). Nevada, Wyoming.

New records.—CALIFORNIA: Fredricksburg (Alpine Co.); 18.VI, 1958.

Host: The species has been collected from *Chrysothamnus* sp. in California.

Discussion: The generic position of *stigmatica* and *labecula* have been discussed by Foote (1959).

8. *Tephritis signatipennis*, new species
(Fig. 2)

Tephritis araneosa (Coquillett) (part); Quisenberry, 1951, Jour. Kansas Ent. Soc. 24: pl. 1, fig. 7.

FEMALE. Head in profile, slightly higher than long; cheek narrow, 0.15 times as high as eye; parafrontal and parafacial regions almost same color as frons; face in profile distinctly concave, definitely projecting anteriorly at anterior margin; frons dark yellow to light brown; proportion of width at vertex to length from vertex to antennal bases as 1:1; face and lunule somewhat more yellowish than frons, heavily pollinose. Antenna yellow, about 0.66 times as long as face; third segment 1.8 times as long as wide; arista dark brown from extreme base to tip. All head bristles light except lower fronto-orbitals, anterior upper fronto-orbitals, ocellars, and inner verticals, which are dark brown to black.

Thorax and scutellum evenly dark gray pollinose without other markings; scutellum concolorous with mesonotum dorsally, but with lighter gray margins seen best from posterior view; postscutellum and metanotum concolorous with mesonotum; mesonotum, scutellum, and pleural sclerites covered with short, blunt, light colored setae; longer bristles black. Halter and legs entirely yellow; anterior surface of all femora very lightly gray dusted. Wing (Fig. 2) mainly dark with the following hyaline areas: A large area from base of wing including cells 1st and 2nd C, cell M and cell 1st A in their entirety, and bases of cells R, R_1, R_3, 1st M_2, Cu_1, and 2nd A; a spot in cell R_1 immediately beyond apex of stigma extending from costa to vein R_3; a rounded spot immediately distad of that spot and a very small round spot usually touching vein R_{2+3} near apex of cell R_1; rounded spots in cell R_3 at apex of vein R_{2+3}, near apex, and three in vicinity of vein r-m, the middle one largest and touching the spot distad of stigma across vein R_{2+3}; rounded spot in cell R_5 at apex, not touching veins R_{4+5} or M_{1+2}, two immediately basad of that spot, and one directly anterior to anterior end of vein m; four spots in cell 2nd M_2, the apical

two nearly spanning the cell; five or six spots in cell 1st M_2; five to seven rounded spots in cell Cu_1; two to four small round spots in cell 2nd A. Dark area of pattern extending to posterior wing margin in all of cell Cu_1 and apical two-thirds to three-fourths of cell 2nd A; stigma without central markings but with a tendency to be light at extreme posterior base and at apex; vein r-m usually not farther from vein m than its own length measured along vein M_{1+2}.

Abdominal terga and sterna concolorous with mesonotum; tergites with short, blunt, pale setae similar to those on mesonotum; ovipositor sheath shining black with pale, short, slender hairs on middle third; ovipositor sheath 1.5 times as long as width at base (from above), about 1.6 times as long as width at base (from below).

MALE. Similar to female in all respects except genitalia, which are subshining black, the claspers with a reddish cast.

Material examined: Holotype ♀, Dardanelles, Tuolumne Co., Calif., 26.VI.1951 (McClay). U.S. National Museum Type No. 64829. Paratypes: CALIFORNIA: 4 ♀ ♀, same data as type (Calif. Dept. Agric. and Univ. of Calif., Davis); 1 ♂, Leavitt Meadows, Mono Co., 28.VI.1951 (Haig) (Univ. of Calif., Berkeley); 4 ♀ ♀, Meyers, Echo Lake, and Wright's Lake, 2-24.VII.1948-1955 (Univ. of Calif., Davis and Berkeley); 1 ♀, Cathedral Lake, Tahoe Co., 4.VII.1915 (Van Duzee) (Univ. of Calif., Berkeley); 2 ♀ ♀, Patrick's Creek, Del Norte Co., 3.VII.1936 (Howell) (Calif. Acad. Sci.); 1 ♀, Mammoth Lakes, Mono Co., 21.IX.1939 (Van Duzee) (Calif. Acad. Sci.); 1 ♀, 1.5 mi. w. of Camp Richardson, Eldorado Co., 24.VII.1955 (Downing) (Calif. Acad. Sci.); 1 ♀, 5 mi. n. Silver Lake, Amador Co., 25.VII.1955 (Schlinger) (Calif. Acad. Sci.); 1 ♀, Gold Lake, Sierra Co., 10.VII.1921 (Fox) (Calif. Acad. Sci). NEVADA: 1 ♀, Ormsby Co., 6.VI (Baker) (Stanford Univ.).

Host: Not known.

Discussion: *T. signatipennis*, originally included by Quisenberry in his concept of *araneosa* (Coq.), is distinct from that species in having a longer ovipositor and ovipositor sheath, the dark pattern extending to the posterior margin of the wing, and a third hyaline spot near the apex of cell R_1 (not shown by Quisenberry). The hyaline mark at the anterior end of vein r-m rarely extends anteriorly beyond the middle of cell R_5. See also the discussion of *araneosa*, p. 84.

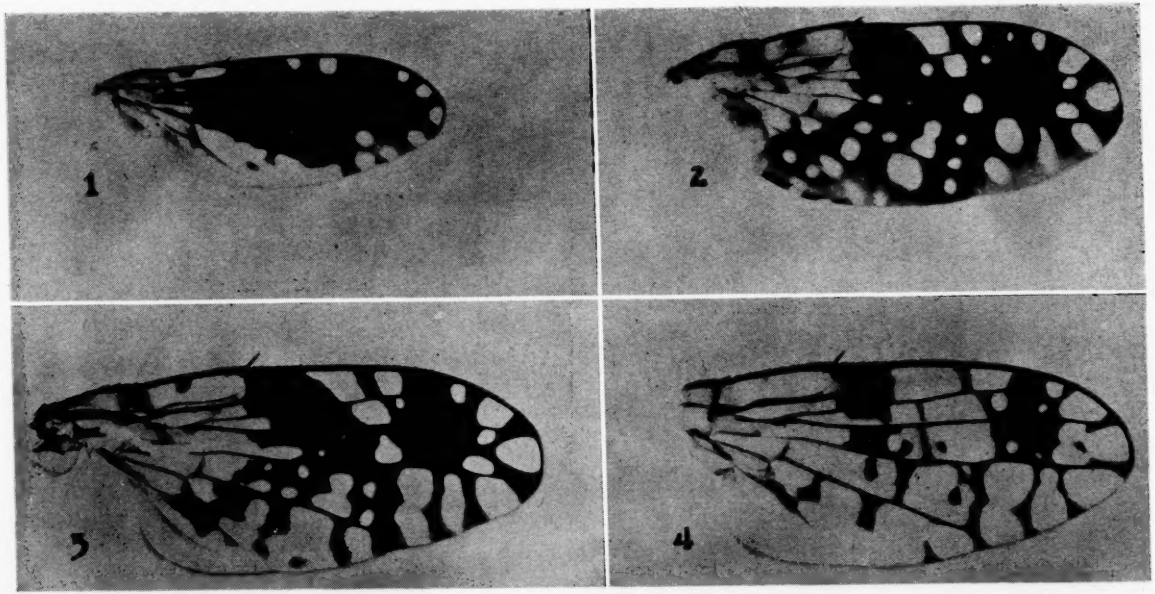
9. *Tephritis angustipennis* (Loew)

Trypeta angustipennis Loew, 1844, Zeitschr. Ent. Germar 5:382; pl. II, fig. 4.

Tephritis angustipennis: Loew, 1873, Smiths. Misc. Coll. 11(256):295. Aldrich, 1905, *ibid.*, 46(1444):611. Hering, 1944, Siruna Seva 5:31. Quisenberry, 1950, Jour. New York Ent. Soc. 58:11. Quisenberry, 1951, Jour. Kansas Ent. Soc. 24:67; pl. 1, fig. 3.

Euaresta angustipennis: Johnson, 1925, Occas. Pap. Boston Soc. Nat. Hist. 7:264. Johnson, 1927, Biol. Surv. Mt. Desert Reg. 1:218.

Previously recorded distribution.—"Scandinavian Region" (t.l.).



Tephritis species, right wing, dorsal view. Fig. 1, *opacipennis*, n.sp.; fig. 2, *signatipennis*, n.sp.; fig. 3, *ovatipennis*, n.sp.; fig. 4, *candidipennis*, n.sp.

Canada: Ontario (Ottawa); Nova Scotia. United States: Alaska (Yukon R.), Maine, New Hampshire, New York.

New records.—ALASKA: Fairbanks and Matanuska; 24.V to 27.VIII, 1943-1945.

Hosts: Yarrow is the only known host in North America for this Holarctic species. It was recorded from *Achillea ptarmica* by Frauenfeld in 1864.

Discussion: Quisenberry's (1951) citation of the reference to the original description of this species is in error; it is correctly shown above. *T. augustipennis* is apparently a rare species requiring extensive collection in the northern parts of North America.

10. *Tephritis webbi* Doane

Tephritis webbii Doane, 1899, Jour. New York Ent. Soc. 7:189. Aldrich, 1905, Smiths. Misc. Coll. 46(1444):612.

Tephritis webbi: Quisenberry, 1950, Jour. New York Ent. Soc. 58:11. 1951, Jour. Kansas Ent. Soc. 24:69, pl. 1, fig. 12.

Previously recorded distribution.—Idaho and Minnesota (both t.l.), California, Colorado, Nevada, New Hampshire, Oregon, Wyoming.

New records.—CALIFORNIA: Echo Lake, Leavitt Meadow, Noose Camp, Sardine Creek, Shaver Lake, Lake Tahoe, Wright's Lake; 4.VI to 6.VIII, 1918-1953. MONTANA: Gallatin Co., 20 mi. e. of Wolf Creek; 19-IV to 31.V, 1912-1956. NEVADA: Ormsby Co.; 6.VII (no further data). OREGON: Eagle Ridge (Klamath Lake); 6.VII, 1924. UTAH: Logan, 16.IV, 1950.

Host: This species has been recorded from the "head of goldenrod" (Quisenberry, 1951) in Oregon; no new data are available.

11. *Tephritis pura* (Loew)

Trypeta pura Loew, 1873, Smiths. Misc. Coll. 11(256):320.

Euaresta pura: Loew, 1873, Smiths. Misc. Coll. 11(256):322. Doane, 1899, Jour. New York Ent. Soc. 7:192. Aldrich, 1905, Smiths. Misc. Coll. 46(1444):613. Johnson, 1925, Proc. Boston Soc. Nat. Hist. 38-:97. Johnson, 1925, Occas. Pap. Boston Soc. Nat. Hist. 7(15):264. Johnson, 1927, Biol. Surv. Mt. Desert Reg. 1:218.

Trypeta (Euaresta) pura: Osten Sacken, 1878, Smiths. Misc. Coll. 16(270): 194.

Tephritis pura: Quisenberry, 1950, Jour. New York Ent. Soc. 58:11. Quisenberry, 1951, Jour. Kansas Ent. Soc. 24:71; pl. 1, fig. 13. Foote, 1959, Bull. Brooklyn Ent. Soc. 54:17.

Previously recorded distribution.—Massachusetts (t.l.), Connecticut, Florida, Maine, Maryland, Minnesota, New Hampshire, New York, Virginia.

New records.—MAINE: Kennebunk Pt. (no further data). MARYLAND: Takoma Park; 18.III, 1944. MASSACHUSETTS: Beverly, New Bedford; 12:IV to 13.V, 1896. MICHIGAN: Houghton Lake; 21.V, 1955.

12. *Tephritis michiganensis* Quisenberry

Tephritis michiganensis Quisenberry, 1951, Jour. Kansas Ent. Soc. 24:68; pl. 1, fig. 8.

Previously recorded distribution.—Canada: Manitoba (Birch River) (t.l.). United States: Michigan (Midland and Cheboygan Counties).

New records.—MICHIGAN: Mecosta Co.; 30.VI to 11.VIII, 1942-1953. Host: Unknown.

13. *Tephritis ovatipennis*, new species
(Fig. 3)

FEMALE. Head in profile, distinctly higher than long; cheek narrow, 0.10 times as high as eye; parafrontal and parafacial regions reddish blue pollinose, contrasting with reddish pollinose frons; face in profile distinctly concave, definitely and sharply projecting anteriorly at oral margin; proportion of width at vertex to length from vertex to antennal bases of frons as 8:7; face and lunule reddish white, lighter in color than frons, heavily pollinose. Antenna concolorous with frons, about 0.9 times as long as face; third segment 1.2 to 1.5 times as long as width at base; basal sixth of arista reddish brown, remainder dark brown. All head bristles light except lower fronto-orbitals, anterior upper fronto-orbitals, and ocellars.

Mesonotum pollinose, light brownish gray with an ill-defined dark central stripe widening and disappearing posterior to suture; pleural sclerites pollinose, darker gray than mesonotum; scutellum very dark gray dorsally, margined with dull yellow; postscutellum and metanotum concolorous with sternopleuron; mesonotum, scutellum, and pleural sclerites covered with short, blunt, light setae, longer bristles blackish. Halter entirely yellow. Fore and mid femora distinctly gray dusted on a yellow ground color; hind femora almost entirely dark gray pollinose and sometimes proximal third of hind tibia; remainder of legs yellow. Wing (Fig. 3) with a dark field restricted by the following hyaline areas: A large area extending from extreme base and filling cells 1st and 2nd C, M, 1st A and most of 2nd A, and basal portions of cells R, R_1, R_3, 1st M_2 and Cu_1; a spot in cell R_1 immediately distad of apex of stigma extending completely across cell and coalescing across vein R_{2+3} with a large spot in cell R_3; a rounded spot immediately distad of that spot, sometimes overlapping vein R_{2+3}; rounded spots in cell R_3 at apex of vein R_{2+3} and at apex of cell; suboval spot at apex of cell R_5, not touching either vein R, R_{4+5} or vein M_{1+2}, two rounded spots immediately basad of that spot, both overlapping aforementioned veins, and an egg-shaped spot in that cell immediately anterior to anterior end of vein m, always broadly based on vein M_{1+2} but never extending completely across cell; cell R mostly dark from level of base of stigma to apex, usually with three small hyaline areas; cell 2nd M_2 with three large spots extending completely across cell; cell 1st M_2 with six to eight rounded spots, two or more of which are usually coalesced, basal one-fourth of cell entirely hyaline; four areas in cell Cu_1, leaving three dark arms completely across cell, the apical one on vein M_3+Cu_1, the basal one broadly connected to a dark area lying upon

basal third of vein Cu_2+2nd A. Dark area of pattern extending to posterior margin of wing only at apical fifth of cell Cu_1; stigma entirely dark except at extreme apex; vein r-m closer than its own length to vein m measured along vein M_{1+2}.

Abdominal terga and sterna dark gray pollinose, concolorous with sternopleuron, somewhat darker than mesonotum; covered with short, blunt, light setae similar to those on mesonotum; ovipositor sheath shining black, dorsally about 1.5 times as long as basal width, ventrally about 1.7 times as long as basal width; basal third with short, slender, light setae, remainder with extremely short, black pile.

MALE. Similar to female except for genitalia, which are subshining black with reddish claspers.

Material examined.—Holotype ♀, Halfmoon Bay, Calif., 3.VII.1947, W. H. Lange, U.S. National Museum Type No. 64831. Paratypes (all California): 2 ♂ ♂, 1 ♀, same data as type (U.S. Nat. Mus.); 1 ♀, Blanco's Corrall, White Mt., Mono Co., 30.VI.1953 (McSwain) (U.S. Nat. Mus.); 1 ♀, Summit, Placer Co., 19.VII.1915 (Dyar) (U.S. Nat. Mus.); 5 ♀ ♀, San Francisco, VI (Koebele) (Calif. Acad. Sci.); 1 ♂, 1 ♀, San Francisco, 29.III.1926 (Van Duzee) (Calif. Acad. Sci.); 2 ♂ ♂, 1 ♀, Sharp Park, San Mateo Co., 5.V.1949 (Beal) (Univ. of Calif., Berkeley); 1 ♂, 8 mi. n. of Ft. Bidwell, Modoc Co., 28.VII.1953 (Bentinck) (Univ. of Calif., Berkeley); 1 ♀, Seven Oaks, nr. Big Bear Lake, 25.VIII.1943 (Jones) (Univ. of Calif., Riverside); 1 ♀, "Hawaiian G.," Los Angeles Co., 21.IX. 1934 (Calif. Dept. Agric.).

Hosts: The type female was collected from *Erigeron glaucus*, and some of the paratypes were collected from *Chrysothamnus* and *Baccharis* spp.

Discussion: Similar in many respects to *signatipennis*, n. sp., but the third hyaline spot in cell R_1 is entirely lacking, and the posterior wing margin is completely hyaline from the base to a point near the apex of cell Cu_1. This species is also a part of the "*araneosa* complex" but was not mentioned in Quisenberry's treatment of that species. See also the discussion of *araneosa*, p. 84.

14. *Tephritis candidipennis*, new species
(Fig. 4)

Tephritis araneosa (Coquillett) (part): Quisenberry, 1951, Jour. Kansas Ent. Soc. 24:66; pl. 1, fig. 10.

FEMALE. Head in profile higher than long; cheek about 0.20 times as high as eye; parafrontal and parafacial regions heavily grayish pollinose, contrasting with dull yellow of frons; face concave, projecting anteriorly at oral margin; proportions of width at vertex to length from vertex to antennal bases of frons as 6:5; face and lunule grayish pollinose. Antenna yellow, 0.75 times as long as face; third segment 1.5 to 1.6 times as long as basal width; arista dark brown from extreme base to tip. All head bristles light colored except lower fronto-orbitals, anterior upper fronto-orbitals, ocellars, and inner verticals.

Thorax evenly light grayish pollinose without other markings; scutellum yellow margined; postscutellum and metanotum very dark gray pollinose;

pleural sclerites covered with short, blunt, pale setae; longer bristles black. Legs yellow; fore femur and tips of mid and hind femora faintly gray dusted. Halter entirely yellow. Wing (Fig. 4) with dark field restricted by large hyaline areas as follows: One large area including all of cells 1st and 2nd C, M, and 1st and 2nd A, basal portions of cells R, R_1 and R_3, basal half of cell 1st M_2, and most of cell Cu_1; two spots filling basal three-fourths of that part of cell R_1 lying distad of apex of stigma; one small rounded spot in cell R_3 distad of apex of vein R_{2+3} and one large one in apex of that cell; three spots, usually confluent, in apical third of cell R_5, cell R_5 with basal third almost entirely hyaline and at least one small rounded spot in central dark area of that cell; several irregular areas in apical fourth of cell R; four large spots almost completely filling cell 2nd M_2, the basalmost two confluent, several very large confluent spots in cell 1st M_2, usually leaving a narrow dark area extending across cell immediately basad of vein r-m, a dark spot immediately basad of center of cell, and several dark areas in apex of that cell; cell Cu_1 with spots so confluent as to leave one dark marking on posterior margin at level of vein r-m, one extending halfway into cell from middle of vein M_3+Cu_1, and at basal fourth of that vein a similar one usually connected with a narrow dark area lying upon basal third of vein Cu_2+2nd A. Stigma yellowish at anterior apical and posterior basal corners; vein r-m slightly farther than its own length from vein m measured along vein M_{1+3}.

Abdominal terga and sterna concolorous with mesonotum; terga covered with short, blunt, pale setae similar to those on thorax; ovipositor sheath shining black, basal two thirds with short, blunt, pale setae, from above about 1.2 times as long as basal width, from below about 1.3 times as long as basal width.

MALE. Similar to female in all respects except genitalia, which are reddish black, subshining, the claspers more reddish than remainder.

Material examined.—Holotype ♀, Fieldbrook, Calif., 31.V.1903, H. S. Barber. U.S. National Museum Type No. 64830. Paratypes: CALIFORNIA: 3 ♂♂, 1 ♀, same data at type (U.S. Nat. Mus.); 1 ♂, Smith River, 17.VII.1930 (Aldrich) (U.S. Nat. Mus.); 9 ♂♂, 7 ♀♀, San Francisco, 13-26.X.1925 (Keifer) (Univ. of Calif., Davis); 13 ♂♂, 5 ♀♀, San Francisco, 11.VI to 8.VIII.1929 (Keifer) (Calif. Dept. Agric.). OREGON: 2 ♂♂, 1 ♀, Roseburg, 24.VI.1957 (Walthall) (Montana State College).

Hosts: The San Francisco paratypes are labeled "ex tansey" and "*Tanacetum camphoratum*." It is not known whether the specimens were reared from larvae feeding on these plants. Quisenberry mentions specimens [as *araneosa* (Coq.)] reared from *Tanacetum huronense* and *Arnica foliosa* in Oregon.

Discussion: The wing pattern of this species is suggestive of that of *araneosa* (Quisenberry, 1951, pl. 1, figs. 2 and 5) and *ovatipennis* (Fig. 3) in the arrangement of hyaline spots. It is evident, however, that the extensive hyaline areas result from enlargement of the various spots. In the material I have examined there are no intergrades between this type of pattern and that present in *araneosa sensu strictu*. *T. candidipennis* may

be recognized immediately by the wing pattern and by the long ovipositor sheath of the female. See also the discussion of *araneosa,* below.

15. *Tephritis araneosa* (Coquillett)

Trypeta (Euaresta) araneosa Coquillett, 1894, Canad. Ent. 26:74.

Euaresta araneosa: Doane, 1900, Jour. New York Ent. Soc. 8:48. Coquillett, 1904, *in* Baker, Inv. Pacifica 1:31. Aldrich, 1905, Smiths. Misc. Coll. 46(1444):612. Cresson, 1907, Trans. Amer. Ent. Soc. 33:105. Cole and Lovett, 1921, Proc. California Acad. Sci., 4th Ser., 11:327.

Tephritis araneosa: Quisenberry, 1950, Jour. New York Ent. Soc. 58:11. Quisenberry, 1951, Jour. Kansas Ent. Soc. 24:65; pl. 1, figs. 2, 5.

Urellia aldrichii Doane: Adams, 1904, Kansas Univ. Sci. Quart. 2:450. Aldrich, 1905, Smiths. Misc. Coll. 46(1444):613. Cole and Lovett, 1921, Proc. California Acad. Sci., 4th Ser., 11:327.

Tephritis aldrichii: Janes and Thomas, 1932, Utah Acad. Sci. 9:103. Quisenberry, 1951, Jour. Kansas Ent. Soc. 24:65 (syn.).

Urellia pacifica Doane: Doane, 1900, Jour. New York Ent. Soc. 8:48. Adams, 1904, Kansas Univ. Sci. Bull. 2:450. Aldrich, 1905, Smiths. Misc. Coll. 46(1444):614. Cole and Lovett, 1921, Proc. California Acad. Sci., 4th Ser., 11:327.

Tephritis pacifica: Quisenberry, 1951, Jour. Kansas Ent. Soc. 24:65 (syn.).

Previously recorded distribution.—Arizona, California (So. California, t.l.), Colorado, Idaho, Iowa, Montana, Nevada, New Mexico, North Carolina, Oregon, South Dakota, Utah, Washington, Wyoming.

New records.—ARIZONA: Fredonia, Ganado, Glenbar, 2 mi. e. of Portal; 22.VII to 3.XI, 1955-1957. CALIFORNIA: 102 localities throughout the state; I through XII, 1902-1958. COLORADO: Brinwood, Cameron Pass, Florissant, Larimer Co.; 17.VII to 15.IX, 1907-1940. GEORGIA: So. Georgia (no further data). IDAHO: Athol, Craters of the Moon Nat'l. Monument, Gifford, 9½ mi. s.e. of Leodora, Long Valley, Mackay, Moscow; 6.V to 30.VIII, 1935-1958. IOWA (no further data). MICHIGAN: Cusino, 26-27.VI, 1940. MONTANA: Bozeman, w. of Scobey; 15-16.VII, 1908-1957. NEVADA: Battle Mt., Ormsby Co., Winnemucka; 9-10.VI to VII, 1933-1958. NORTH CAROLINA: Chadbourne; 30.III (no further data). NEW MEXICO: Datil, Raconda; 18.VII to 25.VIII, 1932-1940. OREGON: 13 localities throughout the state; 9.V to 16.IX, 1896-1953. SOUTH DAKOTA: Brookings (no further data). UTAH: Emigrantico Canyon, Logan Canyon, Parley's Canyon; 2.VI to 21.VII, 1917-1955. WASHINGTON: Bellingham, Pullman, Ritzville, Seattle, Wenatchee; 26.V to 12.VI, 1908-1945. WYOMING: Zion Nat'l. Park; 21.VIII, 1958.

Hosts: Plants from which this species has been reared are cited by Quisenberry as *Arnica foliosa, Artemisia dracunculoides, Poa* sp. (from seeds), and *Tanacetum huronense.* New records have yielded the following names of plants from which *araneosa,* in the sense of the present paper, has been taken: *Artemisia californica, A. heterophylla, Atriplex semibaccata, Atriplex* sp., *Chrysothamnus nauseosus, C. tortifolia, C. viscidiflora, Chrysothamnus* sp., *Erigeron fasciculatum, Erodium cicutarium, Geraea*

sp., *Gutierrezia* sp., *Iris hartwigi*, *Lepidospartum squamulatum*, *Manzanita* sp., *Pectocarya* sp., *Prunus emarginata*, *Salsola kali tenuifolia*, alfalfa, pear, rabbit brush, and white Dutch clover. Adults have also been caught in fruit fly traps in avocado, hackberry, lemon, and orange.

Discussion: *T. araneosa* is the most commonly encountered member of the genus in America north of Mexico. In studying this complex from extensive series of specimens I have concluded that Quisenberry's concept of *araneosa* includes more than one well-defined species. Therefore, I have described *candidipennis*, *ovatipennis*, and *signatipennis*, n. spp., to restrict *araneosa* to a species of smaller size having a very short ovipositor and variations in wing pattern limited to those illustrated by Quisenberry on plate 1, figs. 2 and 5.

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NOTES ON THE BIOLOGY AND SUPPOSED PARTHENOGENESIS OF HALICTINE BEES FROM THE AUSTRALIAN REGION[1]

CHARLES D. MICHENER[2]

I. INTRODUCTION

This paper contains a brief summary of the knowledge of the biology of Australian halictine bees and more particularly shows the fallacy of repeated reports of parthenogenetically produced generations among these bees. (Presumably males are produced parthenogenetically as in other bees.) It is significant that the Australian halictines usually placed in the genera *Halictus* and *Parasphecodes* are all rather closely related and would run to the subgenus *Lasioglossum* s.str. in the key given by Michener (1944).

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It is therefore not surprising to find important similarities in the biology of known Australian forms. The generic name *Halictus* is here used provisionally until a generic study can be completed. It is clear that the Australian species do not belong to that genus (as defined by Michener, 1944) but until it is clear whether or not they should remain in *Lasioglossum*, it seems best not to formally transfer them.

In a series of publications appearing over a period of nearly thirty years, Rayment has written about certain features of the biology of Australian halictines. Since my studies, for lack of time, were largely confined to examination and dissection of halictines taken on flowers, the information in sections II to IV below is largely extracted from Rayment's publications. This summary of the very scattered material in those publications should in itself be useful.

To save space and to indicate relationships, the species discussed are listed below in groups:

A. *Parasphecodes fulviventris* (Friese, 1924); *lithusca* Smith, 1853; *plorator* Cockerell, 1910; *speculifera* Cockerell, 1912; *subfultoni* Cockerell, 1930.

B. *Halictus asperithorax* Cockerell, 1910; *eboracensis* Cockerell, 1918; *goraeensis* Rayment, 1953; *griseovittatus* Cockerell, 1914; *lanarius* Smith, 1853; *leai* Cockerell, 1910; *leucorhinus* Cockerell, 1926; *orbatus* Smith, 1853; *peraustralis* Cockerell, 1914; *seductus* Cockerell, 1914. (Large, non-metallic species.)

C. *Halictus cyclurus* Cockerell, 1915; *emeraldensis* Rayment, 1936; *mesembryanthemi* Cockerell, 1926; *mesembryanthemiellus* Rayment, 1935; *victoriellus* Cockerell, 1914. (Small, non-metallic species.)

D. *Halictus dampieri* Cockerell, 1905; **demissus* Cockerell, 1916; *dimorphus* Rayment, 1955 (nomen nudum); *dotatus* Cockerell, 1912; *erythrurus* Cockerell, 1914; **eyrei* Cockerell, 1918; **fijiensis* Perkins and Cheesman, 1928; *limatiformis* Cockerell, 1922; **phillipensis* Rayment, 1935; **punctatus* Smith, 1879; **raymenti* Cockerell, 1926; *scrupulosus* Cockerell, 1930; *subinclinans* Cockerell, 1915; **suburbanus* Cockerell, 1930; **szentivanyi* Michener, 1960; **tarltoni* Cockerell, 1927; **urbanus* Smith, 1879; *victoriae* Cockerell, 1926; *vitripennis* Smith, 1879. [Small metallic species; those marked with an asterisk (*) have a long abdominal scopa and triangular labral process in the female, the others (except perhaps for *dimorphus* which is doubtful) have an inconspicuous abdominal scopa and laterally angulate labral process.]

II. NEST STRUCTURE

The nests of Australian halictines that have been described are in the soil except for *Parasphecodes wellingtoni* (Rayment, 1951:11), *P. plorator, P. lithusca* and *Halictus peraustralis* (Rayment, 1957:83-85) which nest in soft, rotten wood. The soil used ranges from pure sand to hard paths (Rayment, 1935:302, 330) and from level ground to vertical banks, according to the species. The burrows are not lined with wax. When the tumulus of recently excavacated soil has been removed by the weather, the entrance may be unmodified, or surrounded by a distinct rim (*H. dimor-*

phus, Rayment, 1955:143 and pl. xxi) or prolonged upward as a distinct turret (*H. dimorphus*, Rayment, 1955:145; *H. leai*, Rayment, 1955:147). Rayment does not comment on the constriction of the burrow at the surface of the soil that is characteristic of halictine nests described from other continents. However, Australian halictine nests are presumably constricted at the entrances. Nests of *H. szentivanyi*,[3] which is related to some of the Australian species of *Halictus*, are 4 mm. in diameter, narrowed to 3 mm. at the entrances. Most of the burrows found were lined with soil brought up from deeper parts of the burrow, as could be seen by its color. Likewise, burrows of *H. fijiensis*,[4] another relative of Australian *Halictus*, were lined with soil brought from elsewhere in the nest .

The cells are reported to be unlined in some *Halictus* (Rayment, 1935: 240, 259, 330) but in later publications (Rayment, 1937:33; 1947:84; 1953: 15, 20, 21; 1955:46) mention is consistently made of a very thin membranous cell lining; it seems probable that this was missed in the earlier observations. Of *Parasphecodes*, Rayment (1947:84) says, "The lining is much more evident than the extremely thin skin of *Halictus*, where it is difficult to perceive any lining at all." Probably the Australian *Halictus* do not make such conspicuous cell linings as do halictines that have been studied in Eurasia and the Americas. Unlike halictines elsewhere, some of those of Australia do not make particularly smooth cell walls, the membranous lining being applied over a rather rough surface (Rayment, 1937:33). Although the membranous lining is applied in some species to cell walls of worked earth or sand which can be removed from the surrounding matrix (Rayment, 1955:147), in most species the cells appear as though merely excavated in the matrix and often the membrane merely cements together grains of sand (Rayment, 1953:20). However, in *H. fijiensis* the cell walls seem as smooth as in American *Lasioglossum* and the waxlike lining is about as conspicuous as in the latter.

The cells in most species are more or less horizontal, to judge by Rayment's illustrations, and join the main burrow by very short lateral connecting burrows, as in American species of *Lasioglossum (Chloralictus)* (for illustrations, see Michener and Lange, 1958b: 386, 388), or are at the ends of longer lateral branch burrows as in *H. emeraldensis* (Rayment,

[3] Nests of *H. szentivanyi* were observed by me in flat, firm bare soil of trails at Daulo Pass, near Goroka, New Guinea, at an altitude of 8,200 feet, on May 2, 1959. At that time all nests opened were new, no cells having yet been constructed. Adults of both sexes were common flying over the soil surface. Occasionally males were seen to pounce on females although mating was not observed. None of either sex was seen on flowers. Curiously, both sexes were common flying about and alighting upon excreta of pigs. No nest opened contained more than one female.

[4] Nests of *H. fijiensis* were found by M. H., D. R., D. H., and C. D. Michener in a vertical roadside bank of firm soil at Nadarivatu, Viti Levu, Fiji, 2,700 feet altitude, on June 23, 1959. The burrows were winding, not or little branched, up to 20cm. deep, 3mm. or slightly less in diameter, probably constricted at the surface. The cells were horizontal, connected to the main burrow by very short lateral burrows which were filled with earth as in such forms as *Lasioglossum (Chloralictus) rhytidophorum* (Moure) (see Michener and Lange, 1958b; 386, 388). The cells were smooth walled and waxed, 10mm. long, about 4.5mm. in maximum diameter. Both sexes were common on flowers and were seen flying about the bank. Females were collecting pollen. Among the few nests opened, none contained more than one female.

1937:35). However, in *Parasphecodes subfultoni* (Rayment, 1947: 84) and *Halictus cyclurus* (Rayment, 1955:147) the cells are more or less vertical and in the latter species are close together, forming a cluster which can be removed from the soil intact. There is much variation in the orientation of the cells, and some are probably nearly horizontal even in *H. cyclurus*.

Malyshev (1935) emphasizes the importance of cell symmetry as a characteristic of bee nests. Rayment did not consider this feature, but halictine bees from elsewhere in the world make cells that are bilaterally symmetrical, flatter on one side (the lower surface of horizontally oriented cells) than the others. Presumably the Australian species do likewise, for *H. fijiensis* from Fiji, a member of a group well represented in Australia, makes such bilaterally symmetrical cells.

The food stored in each cell, in all species studied, was in the form of a spherical or nearly spherical pollen mass, sometimes quite dry, in other species moist on the outer surface .The egg, which tapers somewhat toward the caudal end in some species (e.g., *H. emeraldensis*, Rayment, 1937:36) and is of more uniform diameter in others, is always somewhat curved, sometimes very strongly so (*Parasphecodes fulviventris*, Rayment, 1947: pl. viii). It is placed on top of the pollen mass as in other halictids.

Although in his earlier works Rayment mentioned cells left open after provisioning and egg laying, his later works indicate that they are closed immediately after oviposition, and a general statement to this effect (Rayment, 1955:146) for all species studied seems to indicate that he regards the earlier statements as errors. Further discussion of halictine cells left open after oviposition will be given by Sakagami and Michener (in preparation).

For *H. victoriellus*, Rayment (1935:270) was unable to find more than one cell per burrow. It is possible that this bee makes a separate burrow in loose sand for each cell. This is true for *Perdita maculigera maculipennis* Graenicher which also nests in loose sand, although other species of *Perdita* make several cells per burrow as do most burrowing bees.

The number of cells per nest in other species varies according to the number of females inhabiting a given burrow. For nests occupied by a single female, Rayment indicated the following probable numbers of cells (often based on unspecified but small numbers of observations): *demissus*, about six (1935:299); *asperithorax*, about six (1935:309); *phillipensis*, five (1935:313); *dimorphus*, six to eight (1955:149). Nests occupied by more than one female contain correspondingly more cells and the burrows often become much branched.

III. SEASONAL CYCLES

In some species there is but one generation per year (*H. leucorhinus*, Rayment, 1955:143; *eboracensis*, Rayment, 1955:146). In most, however, the bees appear in spring, again in midsummer, and in late summer or autumn, so that there are clearly two or three generations per year. Rayment has shown that in some such species both sexes pass the winter and are active in spring (*H. lanarius*, Rayment, 1953:21; 1955:143, 145; *seductus*, Rayment, 1935:272; *membryanthemi*, Rayment, 1935:281). In most

species, however, only adult females survive the winter and rear a brood of young in the spring. This appears to be true for *Parasphecodes fulviventris*, Rayment, 1947:91; *Halictus raymenti*, Rayment, 1935:240; *victoriellus*, Rayment, 1935:270; *victoriae*, Rayment, 1935:294; *mesembryanthemiellus*, Rayment, 1935:302; *phillipensis*, Rayment, 1935:312; *tarltoni*, *erythrurus*, etc., Rayment, 1935:330; *emeraldensis*, Rayment, 1937:43, 45; *dimorphus*, Rayment, 1955:145; *demsisus*, Rayment, 1955:145; and *goraeensis*, Rayment, 1955:145.

Statements in earlier works (e.g., Rayment, 1935:271) that certain species pass the winter as larvae are not repeated in 1955 and presumably no longer represent Mr. Rayment's opinion. This would certainly be contrary to halictine behavior on other continents. The unqualified statement that there is a single brood in *H. demissus* which winters as larvae (Rayment, 1930:61) is presumably to be regarded as corrected by later work.

In the *Parasphecodes* the summer and fall broods are stated by Rayment (1947) to consist of both sexes, the males of the autumn brood dying before hibernation of the fertilized females. Among most of the species placed in *Halictus*, however, all-female broods which were believed to reproduce parthenogenetically are reported. In *H. raymenti* the midsummer brood is said to consist entirely of females (Rayment, 1935:240) but in most species a midsummer bisexual brood occurs and an autumnal generation consisting of females only is reported. This is the basis for the repeated reports of parthenogenesis in Australian species of *Halictus*. Because males commonly leave the nests soon after reaching adulthood and are in any event short lived compared to the females, errors are easily made if judgment is based merely on discontinuous observations of the bees seen about the nests or on flowers. Excavation of good samples of nests when the young are in the pupal stage would show whether or not males are to be produced in the coming generation. At no point in the studies of Australian *Halictus* are such excavations reported. For *H. emeraldensis* good samples of nests were excavated in the fall (Rayment, 1937:43) and in early spring (1937:45, 46), but these merely showed that only adult females were present in the nests at these times, as would be expected of a species that passes the winter in this stage. These observations do not show whether these females were virgins or not. As will be explained in detail below in the section on dissections, active females of many and probably of all Australian *Halictus* are normally mated and, in reality, there is no significant evidence of parthenogenetic production of females in *Halictus*.

IV. Social Behavior

It is clear from Rayment's publications as well as from my studies that there are no female castes among the Australian halictine species that have been studied. All individuals provision cells and probably none are long lived like the queens of various European and American forms. The generations, therefore, are true generations (each the progeny of the one before) and not broods of worker offspring of a long lived queen as in the case of *Lasioglossum malachurum* (Kirby), for example, in Europe (see

Noll, 1931). There is no evidence that any Australian halictine ever lives to see her mature progeny.

Most Australian halictines, however, are not entirely solitary bees. Some species whose nests have been mentioned (*asperithorax*, Rayment, 1935:308; *subinclinans*, Rayment, 1935:318; and *dimorphus*, Rayment, 1955:143) are not known to place many nests together but most species that have been studied construct their nests in groups. Sometimes the groups are small and rather scattered (Rayment, 1937:34) but sometimes there are enormous aggregations of closely placed burrows (Rayment, 1935:239, 329; 1947:81). The aggregations are sometimes within large areas of seemingly uniform soil, suggesting that the grouping of nests results from some social phenomenon and not merely from utilization of the best location. (For a fuller discussion of the aggregation of bees' nests, see Michener, Lange, Bigarella and Salamuni, 1958a, b.)

In *Parasphecodes fulviventris* (Rayment, 1947:82) and *Halictus victoriellus* (Rayment, 1935:270) there is only one mother bee per burrow, but for all the other species for which such information is provided, a single burrow is often occupied by several females. Wherever the information has been gathered, new nests are started by lone females (*H. raymenti*, Rayment, 1935:240; *cyclurus*, Rayment, 1953:13; 1955:149; *demissus*, Rayment, 1955:149; *dimorphus*, Rayment, 1955:149). The individuals of the next generation, however, re-use the parental nest, so that several females utilize a common entrance burrow. Probably each of the females constructs and provisions her own cells, as is almost certainly the case with the Brazilian *Pseudagapostemon* (Michener and Lange, 1958). When several females use the same nest, the enlargement of the nest is often in the form of a continuation of the main burrow and construction of cells along it. In other cases (*H. dimorphus*, Rayment, 1955:145) new branch burrows are made as extensions from cells. In this case presumably each female constructs a new burrow from her natal cell and makes a series of new cells along the new burrow. In some species (*emeraldensis*, Rayment, 1937:35) the new burrows may start at any point—the main burrow, branch burrows, or old cells. Complicated mazes of interconnecting burrows often result. Up to 60 or more cells may be in use at one time, provisioned by bees utilizing a single entrance (Rayment, 1955:145).

As with *Pseudagapostemon*, it seems that the use of a common nest entrance by several females must be important in the defense of the nest. When the nests are occupied by several females, one of them usually has her head in the entrance and functions as a guard. Rayment states (for *H. raymenti*, 1935:245; *mesembryanthemi*, 1935:285; *mesembryanthemiellus*, 1935:302; *asperithorax*, 1935:308; *dimorphus*, 1955:144; and *emeraldensis*, 1937:47) that each female spends ten to fifteen minutes at the entrance before each of her flights; when she leaves she is replaced by another at the entrance. The result is more or less continuous guarding of the entrance during the time when the cells are being provisioned. Unfortunately the bees were in no case marked for undoubted individual recognition. The same sort of guarding is reported by Claude-Joseph (1926)

for *Paragapostemon mutabilis* (Spinola), a Chilean halictine that nests in similar groups. In *Pseudagapostemon* (Michener and Lange, 1958a), one individual remains as the guard for longer periods, letting the others come and go, although all the females make and provision their own cells. Until the bees were marked for individual recognition, we thought that in *Pseudagapostemon*, too, the guards were merely bees about to leave the nest. It is possible that observational error is involved in the accounts by Claude-Joseph and Rayment. In at least some Australian halictines (*H. asperithorax*, Rayment, 1935:309) the guard, if properly stimulated, turns and blocks the burrow with the dorsum of her abdomen, a reaction very conspicuous among halictines of other continents. Rayment has, on various occasions (e.g., 1937:47) reported the successful driving away of a mutillid parasite by the guard bee; it is easy to imagine the advantage accruing from the use of a common nest entrance because of the more or less continuous presence of guards.

V. Examinations of Female Halictine Bees

As shown in Table I (column 4) a total of 384 female halictine bees of Australian species (column 1) were examined and dissected. (Methods are indicated by Michener, Cross, Daly, Rettenmeyer and Wille, 1955.) (Localities are in Queensland except those marked with an asterisk which are in New South Wales.)

From the standpoint of supposed parthenogenesis, the significant discovery was that virtually all the females collected at random on flowers had been fertilized, as shown by the presence of sperm cells in the spermathecae (column 7, table I). Males in the same collection are indicated in column 9.

It is interesting that in many of the species the number of sperm cells found was small in comparison to American species. In the latter, as described by Michener, Cross, Daly, Rettenmeyer, and Wille (1955) the sperm cells form a hard ball readily separated from the surrounding tissue in fixed specimens. This is to a considerable extent true of certain Australian species such as *H. orbatus*, but in most Australian species the sperm cells form no such firm mass and are most conveniently seen in the uncrushed spermatheca.

There are particularly good samples of bees that must have overwintered and emerged in the spring. These were claimed to be all virgins by Rayment in nearly all species. In central Queensland (Rockhampton and Gladstone), within the tropical zone, there may be no cessation of activity during the winter but in southern Queensland and New South Wales where nearly all of my material was collected, no halictines are active in winter. They were first seen about Brisbane on August 28 and at localities such as Cotton Vale, Legume, The Summit, Guyra, Glen Innes, etc., along the Great Dividing Range, spring activity must start considerably later. It seems clear that all bees collected in August, September, and most of October are overwintered individuals.

A high percentage of the female halictids taken were collecting pollen. In column 5, table I, ++ indicates that all or nearly all those dissected had

TABLE I. Results of Examinations of Female Halictine Bees Collected on Flowers. For explanation, see text of Part V.

1. Species	2. Date	3. Locality	4. Number	5. Scopa	6. Mandibles	7. % with sperm	8. Ovaries	9. Males
H. urbanus	Sept. 14-19	Beerwah	9	++	1-3(1.9)	100	3(3)	0
	Feb. 20	Tamborine Mt.	20	+	1-2(1.5)	100	2-3(2.8)	0
H. dampieri	Aug. 11	Rockhampton	11	++	1-5(3.3)	100	3(3)	+
	Aug. 13	Gladstone	8	+	2-4(2.4)	91	3(3)	0
	Sept. 29	Ipswich	8	+	3-5(4.0)	100	3(3)	0
	Oct. 3	Mutdapilly	4	0	3-5(4.0)	100	3(3)	0
	Oct. 19	Moggill	4	0	1-4(2.8)	75	3(3)	0
	Oct. 21	Condamine	10	+	1-5(3.4)	100	3(3)	0
	Oct. 31	Jimboomba	37	+	1-4(1.8)	100	3(3)	+
	Dec. 4	Brisbane	2	0	4(4.0)	100	3(3)	+
	Dec. 26	Brisbane	10	+	1-4(1.8)	90	2-3(2.7)	+
	Mar. 22	Tamborine	2	0	1-2(1.5)	100	2(2)	0
H. eyrei	Aug. 11	Rockhampton	8	++	3-4(3.8)	100	3(3)	0
	Aug. 13	Gladstone	3	+	4(4.0)	100	3(3)	0
	Sept. 29	Ipswich	2	0	3(3.0)	100	3(3)	0
H. vitripennis	Sept. 29	Ipswich	12	+	4-5(4.6)	100	3(3)	0
	Oct. 3	Mutdapilly	4	+	4(4.0)	100	3(3)	0
	Oct. 5	Capalaba	2	+	3(3.0)	100	3(3)	0
	Dec. 16	Tamborine	6	0	3-5(3.8)	100	2-3(2.3)	0
	Dec. 26	Brisbane	15	++	1-5(3.3)	100	2-3(2.9)	0
	Jan. 1	Samford	22	++	2-3(2.7)	100	3(3)	0
	Jan. 6	Caboolture	9	++	2-5(3.6)	100	3(3)	0
	Mar. 22	Tamborine	2	0	1(1)	?	1(1)	0
	Apr. 8	Capalaba	2	0	1(1.0)	100	1(1)	0
H. subinclinans	Nov. 6	*Glenn Innes	2	+	4-5(4.5)	100	3(3)	0
	Mar. 16	Warwick	4	+	1-4(2.8)	75	1-3(2.5)	0
H. suburbanus	Oct. 20	Helidon	10	+	4-5(4.7)	100	3(3)	0
	Jan. 8	Helidon	15	+	3-5(4.0)	100	3(3)	0
	Mar. 16	Warwick	2	0	3-5(4.0)	50	3(3)	0
H. punctulatus	Dec. 18	Tamborine	5	0	1-5(4.0)	100?	2-3(2.6)	0
H. limatiformis	Oct. 20	Helidon	1	0	3(3)	100	3(3)	0
H. dotatus	Dec. 26	Brisbane	1	+	3(3)	100	3(3)	0
H. scrupulosus	Dec. 8	Lamington N.P.	5	0	2-5(4.0)	100	3(3)	0
H. orbatus	Sept. 29	Cotton Vale	11	++	2-4(3.3)	100	3(3)	0
	Oct. 31	*Legume	10	++	3-5(4.0)	100	3(3)	+
	Nov. 7	Wallangarra	22	++	2-5(3.2)	100	3(3)	+
H. lanarius	Sept. 19	Beerwah	6	++	1-3(2.0)	100	3(3)	0
H. griseovittatus	Aug. 28	Brisbane	8	+	2-4(3.0)	100	3(3)	0
	Aug. 29	Beerwah	5	+	1-3(2.2)	100	3(3)	0
Halictus sp.? (7 sp.)			59			98.3		
P. speculifera	Sept. 30	The Summit	6	0	2(2)	100	2(2)	0

pollen loads on the scopa, while + indicates that some were collecting pollen.

As shown in column 6, table I, the degree of mandibular wear was recorded to give an idea of the amount of work done. Tattering of the wing margins cannot be used in comparisons among species of different sizes, because wings become much more tattered in large species than in small. Therefore the figures in column 6 are based only on mandibles and have the following significance: 1, unworn; 2, slightly worn; 3, well worn; 4, much worn; and 5, very much worn. The range in mandibular wear is shown first, followed by the mean in parentheses. The frequency of considerably worn mandibles is high, even in early spring, and lends weight to Rayment's contention (e.g., 1935:312) that these bees complete their nests before starting to provision cells.

In column 8, table I, referring to ovarian development, 1 means slender ovaries; 2, somewhat enlarged but no oocytes even approaching the size of a ripe egg; and 3, ovaries fully enlarged, usually with at least one egg apparently nearly ready to be laid. The range, if any, is given first, followed by the mean. It is clear that virtually all the bees taken gathering pollen on flowers were egg layers. This is in sharp contrast to the situation among many of the commonest halictines of other continents.

VI. CONCLUSIONS AND SUMMARY

In some Australian halictine bees, each female makes her own nest and occupies it alone. Perhaps in all species nests are started in this manner. In most species, however, some or all of the females presumably produced in such a nest remain there, enlarge it, and occupy it jointly.

The females in such a colony guard the nest entrance, thus providing for common defense, but there is no evidence of other cooperative activity. There are practically no unfertilized individuals; essentially all the females develop large ovaries with large oocytes and presumably lay eggs. Presumably each female constructs her own cells, provisions them, and lays eggs in them. There is no evidence that any female lives long enough to encounter her adult progeny.

There is no good evidence that females are produced parthenogenetically since almost every female has sperm cells in the spermatheca.

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APPENDIX

The species described below is made known at this time in order to provide a name in connection with biological observations recorded elsewhere in this paper.

Halictus szentivanyi new species

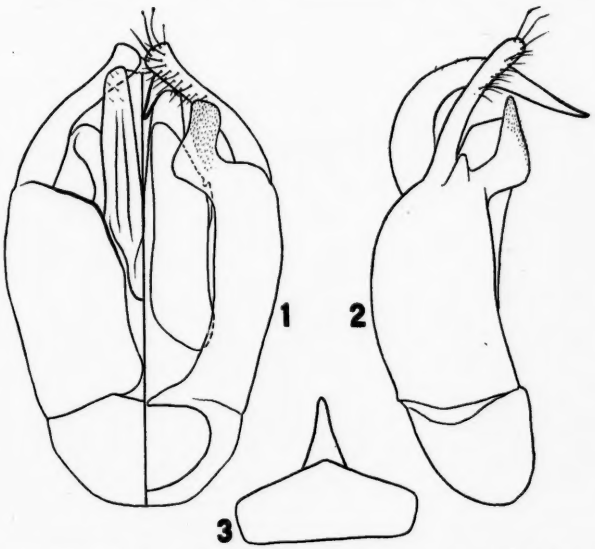
This species is a member of the large group in which the metasoma of the female is flattened, laterally carinate, and provided with a large ventral scopa arising not only from the sterna but from the lateral (ventral) parts of the terga, and in which the process of the labrum of the female is triangular or acuminate, without lateral projections or teeth. This bee falls in the subgenus *Indohalictus* as it is differentiated by Krombein (1951). It differs from other species having the characters mentioned above by the essentially nonmetallic integument, largely fuscous pubescence, dusky wings, etc. Another nonmetallic species is *H. blackburni* Cockerell, but it is a *Homalictus*, as defined by Krombein.

FEMALE. Length 6:5-7.5 mm.; wing length 5.5-6.5 mm. Black, with vague and scarcely noticeable metallic greenish to purplish reflections visible in certain lights on almost all parts of the body; apices of mandibles and margins of metasomal sterna reddish. Wings dusky, veins and pterostigma black. Pubescence blackish; that of clypeal margin and small segments of tarsi rufescent; that of vicinity of antennal bases and lower part of face, under side of thorax, coxae, and scopa of distal half of femur whitish in certain lights; that of posterior and lateral parts of propodeum, vicinity of anterior thoracic spiracle, trochanteral and basal half of femoral scopa

more definitely white. Metasomal scopa consisting of long, dense, branched hairs directed inward from ventral (lateral) parts of terga one to four and similar but more erect and sparse hairs across sterna one to four; scopa of first tergum yellowish, of other terga mostly black but yellowish or white at anterior extremity of each; scopa of sterna dull whitish.

The following measurements are in arbitrary units to show relative distances: head width 55; head length 45; eye length 34; lower, maximum, and upper interorbital distances 32, 38, and 32; interocellar distance 7, ocellocular distance 9, ocellar diameter almost 4, ocelloccipital distance 5, clypeal length 11, clypeocellar distance 31; interantennal distance 8, clypeoantennal distance 8, lengths of first four antennal segments 26, 4, 3, 4. Frontal carina absent; head minutely roughened, median parts of frons and vertex dull, rest slightly shining, hypostomal area and middle of supraclypeal area distinctly shining; lower half of clypeus strongly punctured and at a distinct angle to upper half; punctures of rest of head shallow, scattered, inconspicuous; lower paraocular region without depressed smooth area next to inner orbit; preoccipital carina absent; genal area slightly narrower than eye, seen from side; process of labrum slender acuminate.

Dorsolateral angles of pronotum rounded and inconspicuous; dorsum of thorax dull, finely roughened, with scattered inconspicuous punctures; sides of thorax more shining, finely roughened, with small punctures. Dorsum of propodeum longer than scutellum, finely roughened except for



Halictus szentivanyi. Figs. 1 and 2, genitalia of male. Fig. 3, labrum of female.

shining posterior margin, with about 36 very fine, somewhat irregular but generally unbranched longitudinal rugae which do not reach posterior end of dorsum medially; dorsal and posterior surfaces of propodeum not margined by carinae. Inner hind tibial spur pectinate with about eight teeth; basitibial plate broad and rounded. Third submarginal cell shorter than second; first recurrent vein basal to second transverse cubital (or interstitial); second recurrent and third transverse cubital weak.

Metasoma shining, sparsely pubescent dorsally, minutely transversely lineolate, almost impunctate on terga one to four but fifth tergum distinctly punctate; terga one to three and sometimes four with lateral carina or crease separating dorsal from lateral (ventral) portions.

MALE. Length. 5.5-7 mm.; wing length 5-5.5 mm. Agrees with description of female except for the usual sexual characters; pubescence of clypeal margin, like that of rest of lower half of face, dull whitish; pubescence of venter of entire body, coxae, trochanters, basal parts of femora, much of propodeum, and vicinity of anterior thoracic spiracle fuscous, even whitish at certain angles, but this color grading imperceptibly into the black pubescence of rest of body.

Head measurements: width 49, length 41; eye length 31; lower, maximum, and upper interorbital distances 24, 34, 31; interocellar distance 6, ocellocular distance 9; ocellar diameter almost 4, ocelloccipital distance 5, clypeal length 10, clypeoantennal distance 7, length of first four antennal segments 17, 4, 3, 5. Supraclypeal and hypostomal areas not as shining as in female.

Basitibial plates narrower than in female, apices narrowly rounded.

Metasoma with first five terga largely nearly impunctate, only sixth and seventh more distinctly and uniformly punctate.

Holotype female, allotype male, and 80 paratypes: Daulo Pass, Eastern Highlands District, Northeast New Guinea, altitude 8,200 feet, May 2, 1959 (C. D. Michener).

The primary types are the property of the Bishop Museum, Honolulu, Hawaii. Paratypes will be placed in that collection and in the Snow Entomological Museum, University of Kansas.

This species is named for Dr. J. J. H. Szent-Ivany, Senior Entomologist, Department of Agriculture, Stock, and Fisheries, Territory of Papua and New Guinea, without whose help my work in New Guinea would have been impossible.

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